THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 23. Thursday, May 19, 1921. No. 248.

PUBLISHED WEEKLY.

Subscription Terms: 15s. per annum.
Foreign and Colonial, 17s. 6d. per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI, LONDON, W.C.2.

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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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NOTES AND COMMENTS.

The Question of Apprenticeship.

Great Britain is not alone in her difficulty to induce the right type of youth to enter the foundry business. This difficulty was discussed recently at a meeting of French ironfounders at St. Dizier. M. Umbdem Stock, after pointing out that production, or in other words, work is necessary for the economic reawakening of France, insisted that quality was equally important. Thus the necessity arises for employment of high-class workmen, and to procure these, an effective system of apprenticeship must be established. After lauding the old system which bound a youth to his trade for a certain number of years, then becoming a journeyman (compagnon) from three to five years, after which he was entitled to consider himself a fully qualified craftsman, M. Stock deplored the present conditions, which does not make apprenticeship compulsory, as this results in youths becoming labourers, in order to earn temporarily more wages. An Act of 1919, however, was passed with a view to altering these conditions, by the establishment of compulsory technical, practical, industrial and commercial schools for young men of less than 18 years of age. The speaker considered this desirable on the grounds that the young apprentice, even in well-organised works, only receives practical and material instruction, and the craftsmen who teach him, may be skilled as workmen, but often prove to be indifferent as teachers. Thus, he contended, the apprentice's instruction requires to be completed by lessons on the theoretical side of his business. The apprentice should be given to understand that the moulder's trade is more complicated than is generally imagined, it is distinctly dirty, and requires the expenditure of considerable strength to keep continually ramming sand and moving heavy boxes. Most of the above reads very similarly to many of the presidential addresses given before the various meetings of British Foundry Associations, and clearly shows the peace problems of our Allies are analogous to our own, but this particular question is complicated in France by the intervention of military service, which breaks into the apprenticeship period.

The French have settled their problem by the reintroduction of apprenticeship agreements, in consultation with the trades unions. The apprentices are guaranteed a minimum district wage. In the Paris district it is agreed to pay 65 centimes an hour at the beginning, with half-yearly increments. The apprentice will be bound for four years, terminating on his eighteenth birthday. Should the apprentice have worked well he will be in receipt of 2 francs an hour when his apprenticeship is finished. These figures are adjustable according to the cost of living. Each apprentice is furnished with a book, in which all payments are entered, as it is proposed to give an efficiency bonus ranging from 8 to 20 per cent. of the base rate. This bonus will be paid to the apprentice on the completion of apprenticeship. The theoretical instruction will be arranged for by the various district Employers' Associations, and will be held at the county secondary schools.

This system seems correlated to our own scheme which has been temporarily shelved on account of expense, but we feel confident that the French will carry through their scheme with a minimum of expenditure and a maximum of efficiency, as they do with their large national colleges where they replace the installation of expensive model workshops in colleges by vacation courses spent in the large works. We should imagine that from the French point of view we do things in too "wholesale" a manner in our technical colleges, but a closer investigation of the situation reveals that the difference in industrial, commercial and temperamental conditions of the two nations shows the necessity for the elaboration of our schools. It is probable, however, that our educationalists, when the time comes for arranging apprenticeship courses, will continue on the same lines of installing expensive plant for practical instruction, which can never equal that gained by every-day experience in the works. It would seem that the more important question of the moment is not the education of the apprentice, but the inducing of suitable youths to join the industry. The first consideration is largely dependent on the second, as, once an adequate educational programme for apprenticeship can be submitted to parents, they would immediately realise that the Alpha and Omega of moulding is not "sand punching," but a highly skilled craft, demanding no mean intelligence

A Design of a Foundry for Non-Ferrous Castings.

By H. Skelton and J. C. Moston.

This foundry, shown in Fig. 1, has been designed primarily to meet the requirements of a large electrical and general engineering works, and also to produce castings for supplying outside clients, of a total weight of from 10 to 15 tons per week.

The site for the foundry has been taken as approximately level, and is planned to lay with the length of the foundry pointing approximately North and South, taking into consideration the location of existing machine shop, which is quite near.

Consideration has been given to the position of existing railway lines, and suitable sidings have been laid to suit the requirements of the foundry.

The building is of brick, as shown on accompanying drawing, with corrugated asbestos roof and blue brick floor.

The main foundry is lighted by overhead windows, which are also arranged to open, thereby adding to the ventilation. Electric lights are used for artificial lighting; the smaller machines, troughs, and benches having separate lights.

Air pipes are run, as shown, for the machines and troughs. The sand carrier runway is supported in the wall by means of I iron brackets.

The castings to be produced vary in weight from a few ounces up to 1 ton, and are cast in a large variety of metals, ranging from common brass to high grade bronze and aluminium castings.

This foundry is designed and equipped to employ 30 to 36 moulders, with the usual staff of coremakers, furnacemen, labourers, metal dressers, storekeepers, clerks, etc. For this number of men ample arrangements are made, taking into consideration the Board of Trade Regulations in sanitation, air space, suitable cloakroom, hot and cold water, w.c.s, etc. The building is heated throughout with hot-water pipe and radiator system.

The furnaces, both of the tilting type and pit fires, are coke fired. This was considered to be the more economical method for this particular foundry as it is situated on a coalfield.

All raw materials, such as metals, coke, sand, etc., are delivered to their various stores on rail *vid* the foundry siding.

Internal transport is carried out by means of electric bogies of the accumulator type (Fig. 2). These can be charged up each night ready for use the next day from the works power station. This method obviates the necessity of having narrow gauge lines laid along the foundry floor, thus freeing valuable floor space, and also has the advantage of being able to reach any part of the foundry in very short time.

Pattern Stores.—This section of the building is entirely fireproof, and shut off from foundry by means of fireproof doors. Iron racks are used for storage purposes.

Moulding.—This is divided into three sections. (*a*) Loose patterns are, generally speaking, of such a nature and of such limited quantities that they do not lend themselves either to plate or machine moulding, and are, therefore, made by skilled moulders; the small ones in the moulding troughs, as shown in Fig. 1, and the large castings being made on the floor under the electric overhead travelling crane, which has a capacity of 4 tons, and covers a span of 25 ft. for the width of the foundry. In casting the large castings, the metal is collected in one large ladle of a capacity of 25 cwts. Also, when casting deep moulds the casting pit is used. This lies well under the travelling crane. When this pit is not in use it is covered with iron plates, and thus an economy in floor space is again secured. (*b*) Hand plates are moulded in the moulding troughs, while the various moulding machines easily cope with the more repetition work. (*c*) Moulding machines, which comprise: Three compressed air moulding machines for shallow work, one "Jarring" machine for deep work, and three hand presses for light shallow snap-flask work. Patterns for these are usually made in metal, and a number fixed on sprays.

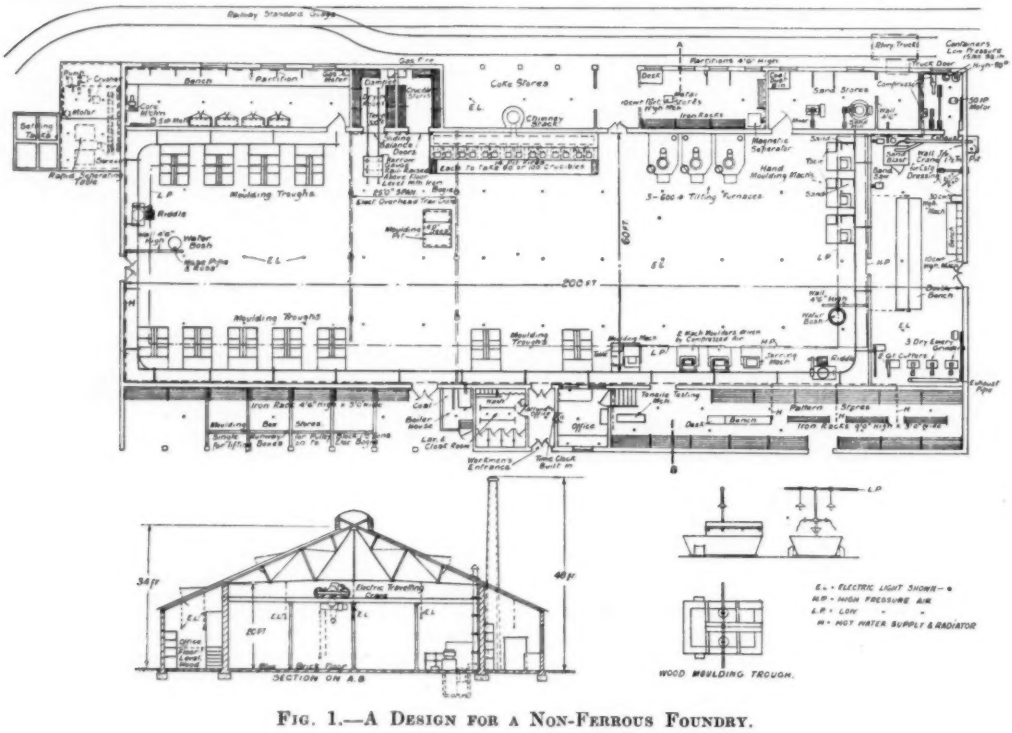


FIG. 1.—A DESIGN FOR A NON-FERROUS FOUNDRY.

Core Shop.—As there are a great number of small cores required, a special core shop is provided, equipped with a power-driven core-making machine of the "screw" type, which makes cores of various sections in large quantities expeditiously and at a low cost.

The benches are used for making cores of irregular shape. Gas-fired ovens are provided for drying the small cores, whilst the large cores are dried in

the drying stove. This stove is provided with a raised rail running down the centre of the stove and extending some 12 ft. into the foundry. An iron carriage is placed on this rail for carrying the large moulds and cores in and out of the stove.

The crucible stores is an adjacent building to the core shop, and has been so designed that it can be at any time turned into a mould-drying stove. Whilst being used as a crucible stores, the gas fire can be so controlled by suitable damping arrangements as to give a temperature of approximately 200 deg. F. After drying, the cores are inspected thoroughly and are then distributed to the moulders by means of hand-barrows. These have handles at both ends which enable two labourers to carry quite a large quantity of cores with very little risk of breakages, etc.

Casting.—Each moulder casts his own moulds. When the moulds are cooled off sufficiently, the electric bogie is brought into use, and labourers,

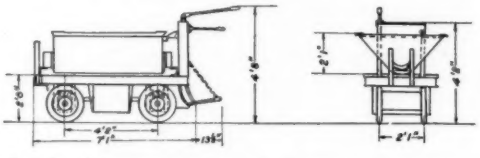


FIG. 2.—ELECTRIC BOGIES FOR INTERNAL TRANSPORT.

after freeing the boxes of weights, clamps, and spilled metal, dump the whole mould into the bogie, castings are knocked out, and boxes returned to the moulder. The object in this operation is to keep the sand clean and free from metal spillings, etc. The sand is then taken to the revolving riddles and prepared for use again. When the castings are quite cold they are collected by the bogie, taken to the dressing shop, and dumped in position ready for dressing operations.

Dressing Shop.—Here the castings of small and medium size have both gits and risers cut off by power-driven git cutting machines. The larger castings have their gits and risers cut off by hand

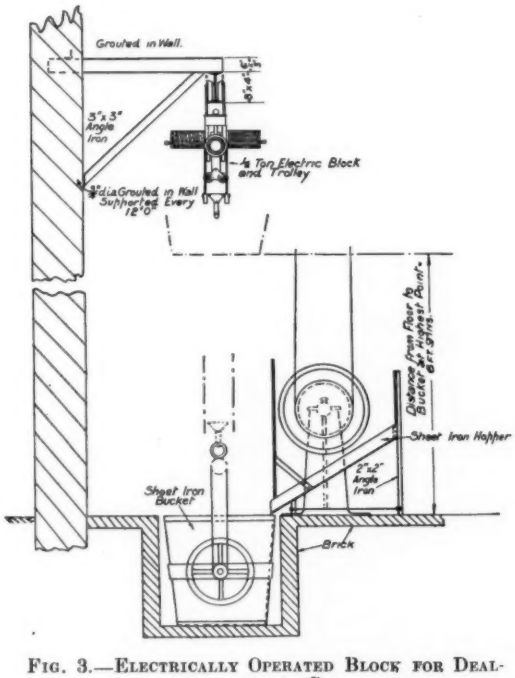


FIG. 3.—ELECTRICALLY OPERATED BLOCK FOR DEALING WITH THE SAND.

or by band saw, according to their size and shape. After this operation, all git remains are ground off on the dry emery grinders. They are then passed to the sand-blast plant. The small ones are cleaned in the revolving barrel, whilst the larger are cleaned in the sand-blast chamber. They are then passed on to the bench, where they are filed and inspected, finally being assembled on the side bench prior to despatch to their destination by electric bogie.

Sand.—New sand is delivered direct to the sand stores. The railway siding enables a wagon to draw alongside the wall, and the lowering of the door forms a platform for transfer of sand to the stores.

Facing sand is then prepared by the sand mill and the centrifugal mixer (driven from a line shaft from the motor and pump house), and afterwards stored in bins ready for foundry use. The electric bogie is used for carrying the prepared facing sand to the moulders and core-sand to the core shop.

The old sand for filling the moulds after being tempered by means of hose pipes and roses connected to water supply over water boshes is riddled in the power-driven revolving riddles and transferred by shoots to hoppers which are hoisted by an electrically-driven block as shown in Figs 3 and 4, and transported along the runway to the foundry troughs, machines, and floor moulders.

Air Supply.—The air supply for power and cleaning is supplied by: (1) A high pressure vertical air compressor, giving a pressure of 80 lbs. per sq. in.; (2) a low pressure horizontal air compressor, giving a pressure of 15 lbs. per sq. in. These compressors are driven by an electric motor in conjunction with the sand mill, mixer, and sand-blast plant, which are driven from a line-shaft from the same motor.

The high-pressure compressor supplies power to the moulding machines, and the low-pressure supplies the sand-blast; also all the machines and moulding troughs for blowing out moulds in place of using bellows.

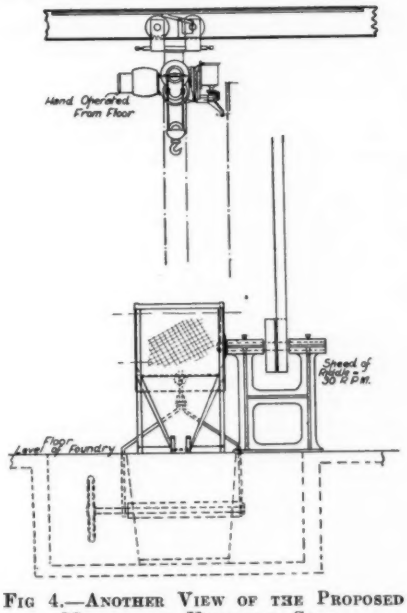


FIG 4.—ANOTHER VIEW OF THE PROPOSED METHOD OF HANDLING SAND.

Melting and Alloying.—All melting and alloying operations are carried out and controlled on scientific lines. Analysis of all raw materials and various alloys is made in the works laboratory. All spilled metal is carefully brushed up, also ashes from the melting furnaces, and passed to the ash washing plant, where the metal is recovered. The process is carried out by means of the following plant: One knapping machine for breaking up large clinkers; one set of rolls for crushing the material before going into the elevator, which carries to the first floor. From this the material passes through a sizing screen, which separates the large clean metal from the small particles, which pass over the "rapid separating tables" and are washed free from sand, coke, etc. The recovered metal is afterwards passed over the magnetic separator, after which it is returned to the foundry ready for remelting and running into ingots.

The "settling tanks" receive the tailings, which are afterwards cleared out and transferred to the refuse heap. When the metal has been recovered it is brought up to standard (after running down into ingots and being analysed) by the addition of suitable new metal.

XUM

Gas-Producer Practice.

A new producer, before being started, should be dried out several days with small fires. This is a precaution which, if properly carried out, will add considerably to the life of the lining. After the producer has been thoroughly dried, all large pieces of wood likely to cause trouble should be removed and the producer filled with ashes to a depth of at least 12 ins. over the top of the blower. It is best that a few large clinkers be placed around the openings of the blower to keep them from becoming clogged with fine ashes. These ashes are necessary to protect the metal parts of the producer. They also act as a diffusing medium to distribute the blast over the entire fuel bed, thus insuring even combustion.

To start the producer, it is necessary only to level off the ashes, throw in several armfuls of small, dry wood, saturated with kerosene, and light with a piece of waste. After the wood has burned for a few moments, turn on about 10 lbs. of blast and blow until the wood is well ignited. A small amount of coal can then be dumped, and the fires be built up gradually. Care should be taken that the coal is not fed too fast. Allow a good bed of coke to be formed before any attempt is made toward crowding the operation of the producer. One should remember that it takes several hours to get a producer fire built up properly to the point where it is making good gas.

No special attempt need be made at this point to get the fire distributed over the entire fuel bed. It will spread itself later, and it is usually better to have a good fire at one point than several small ones scattered over a larger area.

In case it is necessary to stop the producer at any time, the blast should be immediately turned off, and never exceed ten pounds during this idle period.

Measuring Fires.—The usual method of measuring the fires is for the foreman to take a rod about 5 ft. long which he inserts in one of the poke holes in the producer top until he establishes the height of the fuel bed. This method is totally inadequate because no attention is given to the depth of the fire zone, the most important point of all in the operation of a gas producer. If the ash zone is allowed to exceed a reasonable limit, say, 15 ins., the fire zone is considerably reduced, and it is impossible to carry the proper depth of fire if the ashes are not kept within a reasonable limit. This tendency of the ashes to crowd out the fire zone makes it possible for the top of the fuel to be at the proper height and yet the fire may be so thin that the gas will be of exceedingly poor quality.

The only way the fires can be properly measured is to force the rod completely through the fire and allow it to remain long enough to become red hot. After the rod has been withdrawn, it is easy to see the part which has been in contact with the hottest portion of the fire and the part which has been protected by the ashes.

A very convenient rod for this work consists of a ¾-in. gas pipe marked into 2-ft. sections by ¼-in. rivets running through the pipe. A mark is also placed at the height equal to the distance between the blower and the producer top. This indicates the distance the rod should be forced into the producer. The rod is forced through the fuel bed until the lower end is on a level with the top of the blower, and allowed to remain there for two or three minutes. This is usually all the time necessary for the rod to remain in the fire. On being withdrawn, it will be noted that there are two parts which show up distinctly—one a smokey black extending for several feet, and the other a very hot portion usually from 12 to 24 ins. in length. This latter indicates the incandescent zone. Below the lower point of this zone and the end of the rod, there is a portion not affected by the heat, and it should not be very hot. This is the ash zone, and should never be less than 6 ins. and seldom, if ever, exceed 15 ins.

Between the highest point of the hot portion of this rod and the distance determined to the top of the fuel, there will be a space of from 6 to 12 ins. This is the green coal zone. If the coal is of a tarry nature, it is possible that this zone will stand out distinctly by a tarry deposit upon the rod which can be readily distinguished from the sooty deposit above this section. The sooty portion of the rod represents the part in contact with the gas. It is not intended that this method of measuring the fire should be employed more than two or three times per day, depending upon the number of times the fires are cleaned, but this is the only way the ash zone and the fire zone can be measured, and the amount of ashes that it will be necessary to remove be determined.

If the fires are measured just before the change of turns twice a day it eliminates all chance for the men to excuse their own indifference by blaming the other shift for trouble which might be of their own making.

Hot or Cold Gas.—The green coal zone may vary with requirements. If it is intended to generate a hot gas, that is gas leaving the producer at a temperature of about 650 deg. C., the coal zone should not be allowed to exceed 6 to 8 ins. The gas showing when the poke hole cover is removed will be a brownish-black, and a small pilot flame or colour cone of about 3 ins. in length will appear in the centre of the escaping gas. If it is desired to generate cold gas, a deeper layer of coal must be carried over the incandescent fuel. This may be anywhere from 8 to 15 ins., depending more especially upon the nature of the fuel. Under these conditions the gas appearing when the poke hole cover is removed will be a bluish-white, and the temperature when leaving the producer may be as low as 370 deg. C. This is by far the richest and best gas for most purposes. The hot gas usually carries a b.t.u. value per cubic foot of about 150, while the cold gas may have a value of 170 to 180 b.t.u. per cubic foot.

It should be remembered that the change should not be carried to the point where the CO_2 content in the gas becomes excessive, or the fires are so cooled that the carbon in the coal is not properly gasified. Either of these items determines a certain amount of loss, but the situation should be considered as a whole and decision made as to whether the stoppage due to clinkering and the extra labour attendant to the same are not more than an offset for the few percentages of the CO_2 or a slightly increased amount of carbon in the ashes.

Cleaning the Fires.—It is the usual custom to clean the fires about two or three times a day, depending upon the amount of coal burned and the percentage of the ash in the coal.

It is not necessary that the operation of a modern producer be discontinued during the cleaning period. The fire should never be lowered more than 8 to 10 ins. during one cleaning period, and coal should be dumped as during the regular period, although usually in smaller amounts. It is better to lower the pressure on the blowers 10 to 15 lbs. during this period. If two or more producers are arranged to operate on the same line the other producers should be blown slightly harder during this interval, and if this operation is properly carried out, the entire battery of producers may be cleaned without the slightest effect noticed in the operation of the furnaces. During the cleaning period, careful attention should be given to any clinker formations that are likely to appear on the side wall. These should be broken loose and the side walls kept clean.

Points of Interest.—Some coals have a tendency to become soft and pasty under the action of the heat in the producer. This restricts the passage of the gas, and owing to the fact that the pressure accumulates under the steady blast, the gases will seek channels to break through the resistance of the fuel bed. These points then become excessively hot, melting the ashes and other foreign particles in the coal which form the basis of clinkers. If the coal in use is of this nature, care should be taken to see that these channels do not form. This can be done by close attention to the stirring and the regulation of the blast, or it may be necessary to change the mixture of the blast, increasing the proportion of steam to the amount of air blown. This will lower the temperature of the fire and thus considerably decrease the tendency for the fires to clinker.

French Malleable Cast Iron.

In a recent issue of "La Fonderie Moderne" the European method of manufacturing malleable cast iron is dealt with by M. Kluytmans. In introducing his subject M. Kluytmans points out that European malleable cast-iron is only a carbide of iron decomposed by heat in an oxidising mixture (this being a converse operation to cementation). If carbon in a cast-iron exists in the combined, as distinct from the graphitic, form,

Fig. 1.—Micro-Structure of White Cast Iron.

such cast-iron is hard and fragile, possessing a white fracture. Its micro structure will be composed of iron carbide in excess and of pearlite (iron carbide and pure iron in striæ) as shown in Fig. I. After annealing, the iron carbide in excess will be replaced by :—

(1) On the surface of the casting by an envelope of nearly pure iron (ferrite).

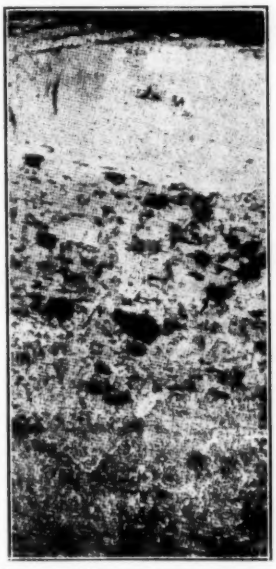


Fig. 2.—Micrograph showing effect of Annealing on the Structure of Cast Iron. The Surface is Nearly Pure Ferrite, the Central Portion Pearlite, Ferrite, and Secondary Graphite, and the Lower Part Pearlite and Graphite.

(2) Between the heart of the casting and this envelope of iron, by a mixture of pearlite, ferrite, and secondary graphite.

(3) The centre of the casting by pearlite and graphite. These phases are shown in the micro-photograph in Fig. 2.

The difference between primary and secondary graphite is that the former is formed during cooling from liquid of high silicon iron, that is grey iron, whereas the latter is formed under the prolonged action of heat. The former is in the form of plates and the latter in the condition of nodules. The object, from the technical aspect, is to change hard and fragile cast iron into a product which will machine easily, can be bent, and will have mechanical properties equal to those of mild steel.

An advantage of malleable cast iron is that it is easier to mould, as the casting temperature is 280 deg. C. lower than that of mild steel. Again, the cost price is lower, at least for castings with sections less than half an inch.

Materials Used.—These consist of white or mottled pigs of definite composition, if the melter desires to produce castings, which, after annealing, give maximum malleability. It is essential, therefore, to be supplied with the analysis of each consignment of pig-iron, and to check them, in order to regulate the composition of the cupola, or other melting media, charges. The author recommends the following composition, which is recognised as giving the best results :—Combined carbon, 2.8 to 3.5; graphite-trace, silicon, 0.80; sulphur, 0.25; phosphorus, 0.06; manganese, 0.15 per cent.

The composition of this iron, having an average silicon content, is suitable for castings of ½ in. maximum section. Below this thickness the silicon can be increased, and above, diminished. The reason for this is that the silicon has the property of precipitating the carbon as graphite during cooling down from liquid. The slower this cooling the greater the time the carbon has to free itself from combination (through the action of the silicon) with the iron to exist in the graphitic condition.

Again, the thicker the casting the longer the time taken to cool, which will give the combined carbon time to decompose, if the silicon is of sufficiently high content that would not allow of the formation of a white-iron suitable for malleablising. The graphite originally present will not be changed by annealing, and will always remain as large inter-crystalline plates, which result in weak places in the final casting.

The silicon content should vary inversely as the thickness of the casting, and the following silicon percentages are recommended:—1/5 in., 1.25; 2/5 in., 1.00; 3/5 in., 0.75; and 4/5 in. and above 0.50 per cent. silicon, other elements being constant.

With regard to the composition of the charges, the melter may have to introduce mottled iron to compensate for the loss of silicon in the remelting of the scrap, forming part of the charge. In such a case the mottled iron should be similar to the white irons used as regards carbon, and possess an analysis as follows :—C.C., 1.6; Gr., 1.9; Si., 1.25; S., 0.25; P., 0.06; Mn., 0.10.

Having established that the silicon has the property of helping the precipitation of the carbon as graphite, primary or secondary, it will be readily understood that the higher the silicon (without going beyond the limit permitted in the composition of the charges and avoiding the precipitation of primary graphite) the more rapidly will the cast-iron become malleablised for a given temperature, or even a lower one for a given time. This explains the few wasters from thin sections, given that the silicon can be higher without fear of primary graphite being formed, which had not time to precipitate on account of rapid cooling during casting.

If the functions of the carbon and silicon as one entity are examined, the former being roughly 2.4 per cent. and the latter round about 1.0 per cent., it will be seen that this iron is less liquid than with a higher carbon content and lower silicon, which will be compensated for by a higher casting temperature, but an iron allowing of easier moulding conditions will be obtained. After annealing this iron will be much stronger. On the other hand, a high carbon content associated with a low silicon content as is necessary for thick sections the question of shrinkage comes in, which on an average will be greater and brings about cracks in the casting.

Sulphur plays an important part in the opposite direction to silicon, as it tends to stop the precipitation of graphite; that is, to conserve it in the combined condition. This influence manifests itself equally on cooling from liquid as on annealing. This being established, it is desirable to keep it sufficiently low in order to allow of the precipitation of secondary graphite, without completely eliminating it as a small percentage allows it to counteract the graphitising effect of the silicon during freezing. As will be shown later, the sulphur has marked influence on the annealing temperature, this varying directly with the sulphur content.

A microscopic examination reveals that the sulphur may exist either as sulphide of manganese or iron. The phosphorus is as important as the sulphur, as it associates itself with the iron as phosphide of iron, which separates out on annealing, forming segregates rich in phosphorus, which give hard spots, for phosphorus is the synonym of hardness. If the phosphorus content is high, but not exceeding 0.30 per cent., it is advisable to lower the percentage of sulphur, and raise the silicon in order to lower the annealing temperature and to avoid the formation of iron phosphide in large masses. Moreover, the phosphorus has a tendency to bring about unequal expansion of the metal, as its melting point is lower than that of the mass of the metal. This melting point being about 950 deg. C., its co-efficient of expansion will be higher. These remarks apply when it is impossible for the foundryman to procure low phosphorous irons. It is essential, therefore, that the phosphorus should be very low. Some foundrymen, especially those availing themselves of scientific methods, prefer white or mottled irons free from manganese. The author does not agree with this, as the sulphur then combines with the iron to form sulphide of iron cells, which makes the iron more fragile, whereas sulphur, existing as sulphide of manganese, forms nodules, which are almost without effect on the fragility of metal, as they do not present continuity in the mass of the metal. The manganese should be kept low, not exceeding 0.15 per cent.

Decarburising media.—Too little attention has been given to decarburising agents, which are generally iron ores, usually hematites or iron peroxides. It is important that the amount of oxygen should be at the maximum and the material used of a homogeneous composition. Should the quantity of oxygen necessary not be available the decarburisation will be incomplete, resulting in hard castings impossible to machine, and, moreover, very fragile if not required to be machined. The hematite used should be brick red, quite dry, and sufficiently hard to resist hand pressure. The ferrous oxide content should be less than 1.25 per cent., and the ferric oxide not less than 82 per cent. Thus the average composition of a good decarburising ore should be as stated, and the other constituents as follows:—Silica, 12.5; lime, 1.0; sulphur, 0.1; water, 2.75 per cent.

If the lime content is higher, it forms during annealing a lime silicate, which, on melting, covers the castings with a hard, dark brown slag, which is not removable by sand blast, and on machining "chews up" the tool, even though the castings have had the requisite amount of malleablising and can be bent without fracture. In such a case the surface of the castings are contaminated with small cracks, almost imperceptible to the naked eye, due to this combination between the silicon, lime and iron. This explains why foundrymen fail to realise the cause of the failure of the annealing. The reaction during annealing is the transformation of ferric oxide to ferrous, the former giving up its oxygen, which acts as a decarburising agent. It has been established that a new decarburant must not be used by itself, as its action is too energetic, and produces a coarse structure in the heart of the casting, and also precipitates graphite in large masses, rendering the casting very weak. Ore should therefore be broken down to pea size, and used material should be mixed with 15 to 20 per cent. of new material to maintain the decarburising properties. It is quite wrong to assume that the annealing temperature should be higher because the ore is poorer in oxygen. It is, of course, natural that if the ferric oxide is low the other constituents will be high. As they are considered as harmful, the results after annealing will suffer. The following analysis shows an undesirable composition, which should be rejected:—Ferric oxide, 65.0 per cent.; ferrous oxide, 3.0 per cent.; silica, 27.0 per cent.; lime, 7.00 per cent.; and sulphur, 0.60.

The silica lime combined to form the previously mentioned silicate envelope, which will be thicker with a higher temperature. This serves to emphasise that all hematites are not suitable for this purpose, and a strict supervision is necessary.

Melting.—The methods of melting are numerous, and can be classified according to quality, cost, and production. First of all, there is the crucible process, which gives a better cast iron than the other processes, but is more costly. After which comes the reverberatory furnace, of which the white-iron product is accompanied by much scrap and a liability to be burnt, if attention has been lacking when melting. Using this method, a stronger iron than cupola iron is produced. Moreover, a reverberatory furnace can be used for melting steel or by varying the combustible, bronze or brass, where a large output is permissible.

The cupola, the commonest method in malleable foundries, should give, when properly controlled, a hot, regular and cheap iron. First of all it is necessary that the foundryman should know the composition of his metallic raw materials, and then the mixtures should be adjusted to compensate for losses and increases of the various elements, and also the composition of the coke, which should have a low sulphur content associated with a low ash. The fixed carbon should be carefully checked, and not be lower than 92.5 per cent., otherwise the deleterious elements will be correspondingly higher. Considering the case of two cokes analysing out as follows:—(1) Fixed carbon, 93.0 per cent.; ash, 5.5 per cent.; and sulphur, 0.75 per cent. (2) Fixed carbon, 89.0 per cent.; ash, 9.0 per cent; and sulphur, 0.5 per cent. Coke No. 1 will be preferable on account of having a lower ash content than No. 2, even though the sulphur may be higher. Preference should be given to cupolas having a receiver, which gives the advantages of a reverberatory furnace and produces a homogeneous iron.

In making patterns, it is necessary to consider that the shrinkage on casting is compensated for by expansion on annealing. As far as possible, the sections of the castings should be uniform, so as to avoid contraction cracks. The runners and risers should be larger than for grey-iron. The sands should be such that they do not melt under the heat. To accomplish this it is necessary to avoid sands containing lime, and to obtain those containing about 90.0 per cent. of silica, and 6.0 per cent. of alumina, the balance being iron oxide.

Annealing.—On this depends the success or failure of the malleability. Having obtained suitable white-iron free from cracks, blowholes, or other defects, and seen that the decarburiser fulfils the outlined analytical conditions, then before commencing it is necessary to establish: (1) The silicon content of the castings in relation to the sulphur content; (2) the lowest temperature at which the carbide of iron will decompose; (3) the influence of total time of heating as well as the time for heating up and cooling.

The first condition can be easily satisfied by analysis. The second will be controlled by the silicon content, as the higher this is the lower the temperature at which the graphite will be precipitated. This data can be utilised by having several furnaces at different temperatures corresponding with castings of the same silicon content, or by placing castings of various silicon contents in the same furnace so as to have the high silicon castings; that is, the smaller ones in the coolest portion of the furnace, and inversely.

It is presupposed that the annealing temperatures will be controlled by pyrometers, which are indispensable if the foundryman wishes to obtain constant results. Such temperatures will be taken in various places in the furnace, high up, front and back, by means of observation holes.

The dimensions of the furnaces will be proportional to the capacity of the foundry. The furnaces will be placed in batteries with common walls, so as to lose the least possible amount of heat. The lay out should be chosen with care, and if the ground is poor, concrete foundations

will be necessary to support the weight and to avoid sinking. As the back of the furnace supports most of the weight the foundations should be balanced accordingly.

The annealing pots or boxes should be made of iron, low in carbon silicon and other impurities, but it is perhaps more economical to cast them from ladles whenever there is a surplus of metal. They are usually without bottoms or covers, and are placed in tiers in the ovens. The castings are placed in these pots so as to obtain an even distribution of the decarburising agent with regard to the thickness of the sections. The heaviest castings are placed low down. Where castings are too big for the pots they are placed directly in the furnace. In such cases the walls of the furnace are covered with cast-iron plates 1 to 1¼ in. thick, rigidly fixed.

The annealing temperatures should be as shown in the following table :—

Showing annealing temperatures for irons of varying compositions :—

Carbon.	Silicon.	Sulphur.	Temperature Deg. C.
2.7 ...	1.2 ...	0.25 ...	870 to 900
2.9 ...	1.0 ...	0.25 ...	880 to 910
3.1 ...	0.8 ...	0.25 ...	900 to 920
3.4 ...	0.7 ...	0.25 ...	920 to 950

In practice the temperatures will vary between 900 and 950 deg. C.

Time of Heating Up and Cooling.—The time factor has as much influence as the carbon, silicon, sulphur, and temperature, and the following must be taken into consideration :—

(1) Time necessary to raise the charge to the required temperature.

(2) Time required to maintain the charge at this temperature.

(3) Time for cooling.

The time is regulated by the shape of the castings. The complicated ones should be brought up to the necessary temperature much more slowly than castings of simple form, 24 to 30 hours being the maximum. Once the temperature is reached the annealing time will be determined by the thickness of the castings and the capacity of the oven. With a furnace taking 10 tons of castings

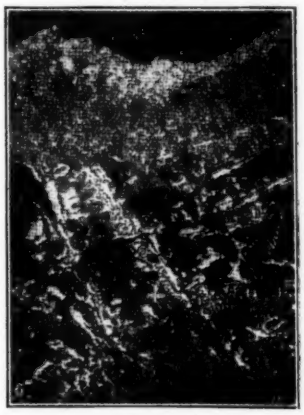


FIG. 3.—MICRO-PHOTOGRAPH OF A HARD CASTING, SHOWING THE PRESENCE OF INCOMPLETELY DECOMPOSED IRON CARBIDE.

of 7 to 10 mm. (¼ to 7-16 in.) section will be about 72 hours. For heavier sections the time may reach 100 hours.

Many foundrymen imagine they can, by annealing at a higher temperature, reduce the time. The time gained will be cancelled by increased fuel consumption, for if for 10 tons of iron plus about 10 tons or ore and 5 tons of pots, and taking into consideration the hearth and walls of the furnace, a definite number of heat units are required, and assuming the temperature of annealing at about 920 deg. C., it would be necessary to introduce a much larger number of heat units to raise the temperature to 1,000 deg. C., using up about 10 per cent. more fuel. Further, if test-castings are required by the customer they will be found to be fragile, due to a too-high annealing temperature. The cooling time is important, as on this depends the production of hard or malleable castings. If the castings are withdrawn from the furnace as soon as time of annealing temperature is reached, unmalleable, hard white castings will result, the reason being that under the prolonged heating action an austenitic structure is formed, and it is necessary that this structure should decompose by very slow cooling, which allows of its transformation through the martensitic range to the pearlitic structure. Should quick cooling take place at temperatures corresponding to either the austenitic or the martensitic range then hard castings will be produced. Obviously, sufficient cooling time must be given in order to have easily machinable castings—the time varying between 24 and 48 hours. In no matter what case the furnace openings must not be demolished before the temperature is below 670 deg. C., this temperature being given because the pearlite transformation point is 690 deg. C. Moreover, the decomposition of iron carbide continues during the cooling period, which should be complete at the end of the cooling, but above 690 deg. C. If the decomposition is incomplete, hard castings will result, as shown in the micro-photograph (Fig. 3), where the presence of incompletely decomposed iron carbide can be seen.

Such a defect can result from (1) Too weak a decarburiser, annealing temperature and time being normal. (2) Too short a time (including quick cooling) for normal temperature and decarburisation. (3) Too low a temperature for normal time and decarburiser, in which case the pyrometers should be periodically checked.

Obviously such castings will be impossible to machine once the skin is removed.

A further cause of failure producing the same effect as a too-high annealing temperature is the overheating produced by a too-prolonged annealing time. If the necessary time is exceeded a too great a decomposition takes place, and the normal pearlite will be decomposed into graphite and ferrite-forming cellules, which, from a practical standpoint, give large crystals.

If malleable cast iron is analysed after annealing the following results are given :—

Total C.	C.	CC.	Gr.	Si.
Before ..	2.90 ...	2.90 ...	— ...	0.60
After ...	1.87 ...	0.57 ...	1.30 ...	0.60

Mechanical Results.—Taking into consideration only trial castings which have been cast and annealed according to the outlined conditions, the tests carried out on the tensile strength, the elastic limit, elongation, reduction of area and bending, the results given are the means of numerous tests.

Maximum Stress. Tons p. sq. in.	Elastic Limit. Tons p. sq. in.	Elongation per cent.	Reduction of area per cent.
24.0	20.0	8.9	3.6

Bending test on 1 in. 60 degrees.
,, ,, on ½ in. 110 degrees.

Conclusion.—The foundry should be conducted on the most scientific lines possible, analysing all raw materials. Knowledge of causes of failure is the sole method of preventing or remedying them.

AMERICAN pig-iron production in April constituted a new low "record," amounting to 1,183,000 tons, against 1,596,000 tons in the previous month, and 2,700,000 tons in April last year. The weekly average output at the beginning of the present month was 270,000 tons, against 305,000 tons last month, and 624,000 tons last year.

THE works of Messrs. John Bradley & Company at Stourbridge and Messrs. John Bagnall & Sons at Wednesbury are undergoing considerable improvements or extensions. The former are bringing their forge department up-to-date by the addition of Siemens gas furnaces, and the latter, who for some time past have had Siemens furnaces laid down, are extending their forge. Messrs. Bradley are the owners of the celebrated S.C. marked bar brand which, it may be recalled, originally took its name from Stourton Castle, the residence near Bridgnorth, Shropshire, of the great Foster family of ironmasters.

Safety in Foundry Equipment.*

By A. R. Bartlett.

Whilst some foundries have been provided with every reasonable protection against accident to both employees and plant, others have made no effort at all—not on account of any lack on the part of employers to recognise their obligation, but rather from a lack of knowledge of the subject. Improvements can be made by a careful study of working conditions in each individual foundry and the enlistment of the sympathy of the employees towards safety equipment. The earnest co-operation of everyone concerned is essential to the complete success of every scheme. The general condition and appearance of the foundry is greatly improved where safety is regarded seriously, and thus becomes a more desirable place in which to work. Moreover, orderliness in the foundry adds to production and accidental injuries are greatly reduced. Every workman is a producer, and if through a lack of caution he is placed on the sick list the output is reduced due to his absence, therefore it behoves everybody to aim at the workman's protection, and the workman himself to co-operate, as, while absent, he is both a loser in wages and a sufferer.

As a general rule accidents in foundries occur when someone, labourer, moulder, foreman, or manager, does not take sufficient care. Accidents can usually be ascribed to the following causes:—Neglected orders, horseplay, improper handling of metal, cranes improperly loaded, a badly-prepared ladle or insufficiently dried, the defective shoe, ragged or turned-up trousers, lack of protection for the eyes at the cupola, emery wheel, or shot-blast chamber, falling stacks of pig-iron, crushing hand or foot, the neglect of cuts and small wounds, becoming septic often leads to serious trouble. Other causes are:—Dampness where molten metal is to be poured, causing explosions and serious burns, unevenness in foundry floors and obstructions in gangways. The little heaps of scrap and rubbish, the tools and tackle lying where it was last used, instead of being stacked and stored in properly arranged bins or places, where everyone knows where to find it again, instead of the continual hunting around for the different small items that are required, can swell the list of preventable foundry accidents and help to reduce production in every foundry where insufficient thought is given to safety.

Sometimes risks are not clearly seen, through familiarity of conditions, and the danger does not impress itself on the minds of those implicated. But whether danger threatens openly or concealed, a wholesome respect of danger decreases danger, while thoughtlessness and carelessness contribute to its increase.

Thus it is established that the employer, by providing reasonable and sufficient appliances, the careful oversight of foremen and manager in the direction of the men, the cautious regard of the man for his own safety and that of his fellow-workmen, are basically necessary for safety in foundries. This might be condensed and termed a mixture of wise management, example, counsel and discipline.

It would be expected that the common sense of the workman would make him practise caution in his work, yet we find him taking chances which seem to be handed down by previous generations of workers, who consider accidents as a matter of course, whereas they are invariably the result of carelessness.

Education in respect of safety must originate with the employer, his initiative and intelligent supervision count most in this direction. The foreman is at fault who encourages disorder or carelessness, and a preventable accident is a disgrace to the foreman. By example and judicious counsel the workman will feel reproach attached to himself, who through neglect of instructions endangers the safety of anyone in the shop. Also he will not allow wrong conditions to remain which may contribute to the injury of anyone without protest to his foreman. Neglect of such an obvious duty makes the workman a menace to himself and to his fellow workers. Additionally to the human aspect of safety, there is the economic phase which should appeal to all employers. It pays from every point of view, the greater loyalty of the employee and the reduced financial liability owing to the reduction of injuries. Obviously, it pays in the greater production that safe and orderly methods promote.

Danger Signs.—These should be placed in conspicuous positions where danger exists. A notice reading: "Be careful—there is danger here," cannot be ignored by any sane person. These signs could with advantage be placed where there is any hazard. For instance, at the door leading on to railway sidings, where the thoughtless might run under a locomotive, or where repairs are being carried out overhead and the danger is obvious from falling tools or materials. All signs should be made distinctive and striking, so as to catch the eye and impress the mind. A distinctive colour scheme, such as a red background, accompanied by reasonable-sized letters that stand out well, preferably in white, should be adopted. The letters should be sufficiently large to be distinguished easily by approaching persons In every foundry investigation will show where danger signs can be advantageously placed. By such means risks are combated by anticipation.

The Foundry Yard.—As a storage ground for moulding-boxes, pig-iron, sand, or other bulky materials awaiting the various demands of the foundry proper, the foundry yard is more economical for storing materials than the shop, as the overhead charges are comparatively small, and the foundry interior should be used for manufacture as far as possible, and thus paying for the rates and taxes payable thereon.

The foundry yard should be an orderly place, as order makes for safety and promotes efficiency. It is thus rendered more commodious and accessible. Not only will congestion be relieved, but light will be able to penetrate, and thus reduce the lighting bill. Such conditions will be appreciated where floor space is imperative and the foundry is required to be really productive.

The foundry yard should be kept flat, and provided with safe and efficient foundations, in order that heavy materials may be stacked. Boxes should be kept in orderly fashion, so that when requiring any particular one it is easily obtained. Each size of box should be stacked apart, or if not in sufficient quantity, the larger box should be at the base of the stack. Gangways running between the stacks enable the boxes to be readily measured, so that the right box is procurable, instead of substituting with one too large or small. Saved time, increased production and added safety are thereby ensured. Pig-iron must be properly stacked, for the pile that slips invariably traps the fingers, crushes the foot or barks the shin. Gangways between all stacks should be sufficiently wide to enable barrows or a light railway to run without risk of injury to workmen by catching their hands against the stacked pig-iron. All walks should be made up with ashes or other dry material, to enable transit to be easy and to avoid damp feet in wet weather. If pits are in use for any materials, substantial guard rails should be placed round them, for whereas this may not be needful during daylight, on dark days there is the possibility of someone falling down them. Therefore the orderly foundry yard makes for safety.

The Foundry Floor.—It is here where most risks are taken as spilt molten metal is the cause of the majority of accidents in the foundry. The sand on the ground under the runner box of the job to be poured should be loosened. This will stop the metal that fails to enter the runner box from splashing, as the loose sand allows the metal to sink into it and be retained, whereas if it falls on hard ground it would fly, possibly resulting in injury to workmen.

Obstructions in gangways are often the cause of the man carrying a ladle of metal stumbling, with the result of risk of burns to himself and his shop-mates. The narrow winding path around irregularly-placed boxes often results in the ladle catching against the boxes and spilling the metal, whilst climbing over boxes and heaps of sand has

* Lecture recently given before the Lancashire Branch of the Institution of British Foundrymen.

the same effect. Heaps of sand and badly-arranged boxes are often the contributory cause of accidents, when the men, in their haste to get away from flying metal, fall over them and not only get cut and bruised, but often more severe burns than would have been the case. Obviously, a clear path is more easily obtained in a shop where work is standardised than in a jobbing foundry.

It is well to keep the floor clear from everything that will hang up; this not only prevents possible accidents, but promotes emciency, for tools can be found when wanted. Advantages are derived from having some of the floor staked off, so that only a small class of work can be done there, thus keeping the paths clear where metal-carrying by hand is in vogue.

Neglect to see that there is sufficient room for the ladle and the men manipulating it, when the metal is being poured, is liable to cause spilling. Clamps, skimmers, wedges, rammers, rods, or any tackle must not be thrown from the top or side of the box just cast, while metal is being carried, demoulding should be carried out after pouring is finished. The adage, "A place for everything and everything in its place," is particularly applicable to the foundry. Surplus metal poured where it is likely to be trod in, or if allowed to be covered with sand whilst liquid, are dangerous practices. It should be borne in mind that the foundry floor is for moulding; therefore, patterns should be removed to a proper storage place, as they constitute a stumbling-block if left lying about, and are liable to be spoilt if hot metal touches them Barrows or other large tools should not be kept in the foundry when not in use. An orderly shop undoubtedly attracts the most efficient workmen.

Ventilation and Lighting. — The foundry is extremely dusty, and requires that the floor should be kept sufficiently damp to stop the sand becoming dust. According to statistics, the foundry has the most dusty and impure atmosphere in the manufacturing world, and from the death returns of moulders, the greater number die of chest complaints, largely due to this factor. The better condition in which the shop is kept, the more likely is it that a good class of workmen will be obtained, for the best men appreciate good working conditions.

Windows must be kept clean, as the better the natural light, the less likelihood of accidents, and the cost of artificial light is reduced. To assist the lighting arrangements all walls should be regularly whitewashed. This is also necessary for hygiene. Light must not be obstructed by badly-arranged machines or stacks of boxes.

Artificial light is essential for dark days, but it should be so placed that no dark shadows are thrown from it, and that it should be of good quality and sufficient quantity to make the foundry a workshop and not a coal cellar. Good lighting pays for itself, for accidents are avoided, more work is done, eyes are not being strained and injured, and thus the work is more efficiently produced.

A well-ventilated foundry tends to prevent accidents for the reason that the health of the workmen is maintained, and a healthy man can take interest in his work. Such a shop allows the fumes from molten metals to get away, and especially is this so in the non-ferrous foundry where the fumes from zinc may adversely affect the health of the men. Much objectionable smoke arises from core ovens and moulds, especially those containing large cores, or cores where straw or hay has been used.

Core binders, pickling tank, sand blast, open fires and other methods of drying all contribute to the unpleasantness of the foundry.

Some sand-blast risks have been lessened by the use of respirators, but for the majority of foundry workers the ventilation of the shop is the only safeguard, and natural ventilation, as a general rule, is the only one used. A good installation of forced draught would remove most of the fumes and dust associated with the average foundry. In the sand-blast process it is usual to employ some form of forced draught, but even here a want of care has been noticed on the part of the operator, for though helmets, gloves, and respirators are provided, it is quite usual to find them discarded and the operator running unnecessary risks.

Badly-arranged ventilation causes great unpleasantness by draughts, and as most foundries have no proper heating arrangements, an open coke fire is used and so placed that it warms the cold draught, but in doing so an added discomfort is put in the shop by reason of increased fumes.

It is now usual in a modern brass foundry to instal ventilating hoods over the furnaces, thus assisting in clearing the shop and conserving the health of the workers. If oil or other binders which give off a large amount of smoke are thoroughly mixed with the sand, the resultant smoke is not so great as in an insufficiently mixed compound. If, however, the oil is thoroughly mixed, a smaller quantity is needed.

All fires that are lit with wood should be allowed to get well alight before coke is added. This specially applies to open ladle fires. The rumbler or tumbling barrel is a prolific cause of dust, and should be placed in some part of the shop where the least number of men are working, or, if possible, in a room with a forced draught.

Cranes.—The crane in the foundry being one of the chief tools, it should be safely equipped and carefully operated. If a mould or a core should fall it is ruined, and if it should happen to fall on other work that also is spoilt, and if it should fall on any of the workmen injury is the result. If molten metal is dropped from the crane there is the added danger of burns. Generally speaking, all risks from loads falling from cranes can be avoided by careful driving and slinging, and a strict inspection of the crane parts. The hoisting chains, wire ropes, and gearing should be periodically examined. The brakes should be maintained in perfect order. Lubrication of all moving parts is absolutely essential, including that of the wire rope or hoisting chain. Dust accumulating on the crane is found equally in the grooves of the hoisting drum and other working parts, and should be removed. If a surplus of oil is given, it holds the dirt, rendering the crane liable to breakdown. The oil, overflowing from bearings on to the platform of a crane, where dirt is allowed to accumulate, makes slippery places for the crane-man or millwright, bringing in the possibility of a slip with disastrous consequences. An excessive use of oil is not only a waste, but it is a nuisance to the men working underneath.

Sudden stops and starts should be avoided, for undue strain is put on every part of the crane, including the chains and ropes. If the chain-links or wire ropes appear faulty, they must be removed, as it is far cheaper and safer, for loss and injury are avoided. Dirt helps to wear out the teeth in the gear wheels, for teeth, if they start to strip, fly off very quickly, and the impetus thus given to them is obviously dangerous. Some cranes have gear cases, which is undoubtedly desirable. Though electrically-driven cranes always have enclosed motors, it is found that these should be regularly examined, for, if neglected, stoppages take place and may possibly cause delay. The insulation of the wiring, if neglected, gets worn and the system endangered through short circuits. Exposed wires must be insulated, as shocks can be severe, and if the man falls he is liable to receive very serious injury. A safe means to get to and from the crane cab is essential. The ladders should be permanently fixed to the end of the shop.

A very serious accident once occurred through a ladder being placed in the middle of the shop. The driver of one crane was coming down and another crane was travelling up the shop at the same time. No one noticed the man coming down, with the result that the crane passed over one of his hands, permanently injuring it. If the ladder had been at the end of the shop it could not have happened.

A hand-rail should run round the footwalk of the crane, and to have a board on edge to prevent any tools from falling off is desirable. It is preferable to provide the crane-man with a tool-box and to see that he uses it. He should be provided with sufficient oil and waste for his requirements, and allowed ample time for cleaning.

To lift more than the crane is designed for is dangerous, and therefore the lifting capacity of the crane should be plainly marked in a conspicuous position, with figures large enough to be seen easily from the ground.

(To be continued.)

XUM

Cast Iron.—III.*

The Strength and Properties of Castings.

(*Continued from Page* 380.)

By E. L. Rhead.

It is obvious that in cast iron which is both highly carburised and siliconised there is no doubt of the complete separation of the phosphide eutectic. As little as 0.1 or 0.2 per cent. of phosphorus produces a eutectic that can be found on microscopic examination as a distinct body, and the amount increases as the proportion of phosphide increases. Its appearance is shown in Fig. 4. It is not always easy to distinguish it with certainty from the iron and iron carbide areas, and not infrequently the author has found areas in which the carbide graphite separation has resulted in the production of a herring-bone structure (like the shading of a range of mountains) in the neighbourhood of graphite, described as phosphide. In one instance the material turned out to be Swedish iron, with less than 0.03 per cent. of phosphorus. With reasonable discrimination, however, it can be made out with certainty, and also by heat testing.

There is evidence to show that the presence of phosphorus actually lowers the total carbon contents of iron, but the amount present in foundry irons does not seriously reduce the percentage of carbon. Such irons always exhibit a lighter

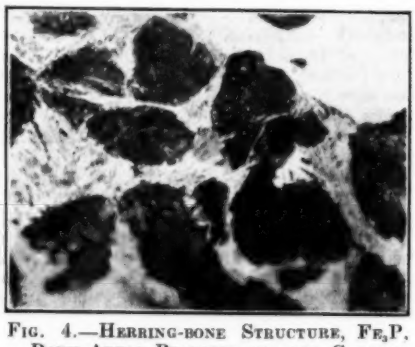


Fig. 4.—Herring-bone Structure, Fe_3P. Dark Areas Pearlite and the Central Crystal Sulphide.

colour, with the same carbon contents as less phosphoric iron or otherwise similar composition, but this is due to the whiteness of the eutectic which they contain.

Influence of the Phosphide Eutectic.—The low melting point of the eutectic permits crystallisation to proceed freely. In castings containing 1.5 per cent. of phosphorus the author has found the eutectic to contain 6.55 per cent. of the element corresponding to 23 per cent. of the eutectic. This nearly corresponds with Wüst's figures, who found that the addition of phosphorus to a saturated iron-carbon alloy lowered the melting point until 6.7 per cent. of phosphorus was reached. Further additions tended to raise the melting point. This eutectic has a melting point of 950 deg. C. The temperature at which separation commences is uncertain, but irons that contain very small amounts, and whose solidification is practically completed at high temperatures, show the presence of separate phosphide eutectic.

Influence on the Carbon.—So long as the phosphide remains uniformly dissolved its effects on lowering the solidifying temperature is general. If the carbon saturation be high, and the silicon contents be also high, a point may be reached at which temperature the carbide may be precipitated, decomposing into graphite, as previously stated, the graphite growing in size as long as free movement is possible. These graphite flakes interfere with and prevent the development of a structurally strong arrangement and crystallisation.

Several writers have called attention to the great variation of strength in phosphoric iron. Cook stated that when phosphoric irons had a meshed structure they were strong, and when they had a confused structure they were weak, and concluded that the phosphorus either raised or at least did not lower the strength of the metal. The true explanation, we submit, lies in the fact that in irons presenting the meshed structure the normal growth of iron-rich crystals has proceeded prior to the saturation point of the carbide being reached, the growth of objectionable graphite crystals has not occurred, and the internal structure has been mechanically sound. That this is the course of procedure appears probable from the manner in which phosphide pellets are formed. The fused eutectic is forced from between the inter-crystalline spaces by the contraction of the interlocking crystals, which have at that temperature developed strength which resists fracture and ensures continuity. Specimens were shown taken from a cavity in a tool bed which contained only: P 1.1, Si 1.5, Mn 0.7, C 3.0, S 0.1.

The bigger the casting, involving the slower cooling and consequently greater activity of the silicon and carbon, the smaller should be the proportion of these constituents within the bounds of the possibilities of making the castings. This is borne out in the series of test-bars, of which Table IV. gives the particulars:—

Table IV.—*Showing the Influence of Phosphorus on the Transverse Test of Cast Iron.*

No.	Transverse load.	Si.	Mn.	P.
	Cwts.			
1	30.00	1.9	0.4	1.00
2	34.50	1.8	0.4	0.70
3	37.50	1.6	0.7	0.50
4	40.00	1.4	0.7	0.50
5	43.00	1.3	0.9	0.30
6	45.75	1.2	1.0	0.25
7	29.00	1.0	0.8	0.60
8	21.00	0.9	0.4	0.15

Size of test bar 2 in. by 1 in., and length between supports 36 in.

To obtain strong, tough, sound castings, the phosphorus content must be as low as possible. This especially applies to large castings required for heat-resisting purposes. Its effect on the strength is shown by No. 7 bar. For the latter purpose the low melting point of the eutectic is the drawback.

No. 8 showed chill, and to that the reduction in strength is attributable. Sharp chill invariably reduces strength. In these cases the casting conditions were unsatisfactory for the iron for such sections, and probably in larger sections very strong castings might have been attained.

The advantages of low carbon, low silicon, low phosphorus iron for strong castings, is generally recognised by the improvement in strength resulting from the addition of wrought-iron and steel scrap to the cupola charge—the so-called semi-steel of the ironfounder. These additions all tend in the directions indicated, and their success depends on establishing the conditions laid down, the most important of which are melting at such a high temperature that the pig-iron and steel become perfectly dissolved. Low melting-point irons are unsuitable on account of the disparity in their melting points. Melting at the minimum possible temperature is liable to produce an unsatisfactory result, due to components beginning to fall out of solution before the pouring is complete and the mould filled.

Brittleness.—The phosphoric eutectic is very brittle and hard. It has no toughness or ductility, hence the low resistance to shock of phosphoric irons, especially those of irregular structure. Fig. 5 shows a specimen of phosphoric iron of the following composition:—C 0.07, Si trace, Mn trace, S 0.045, P 2.00, which was very slowly cooled. It was taken from the bed of a steel furnace that had been shut down. It will be observed that the metal has acquired a very pronounced cubic cleavage and is exceedingly brittle.

* Extracted from the Journal of the Manchester College of Technology.

As a further result of the fusibility and fluidity of the eutectic the formation of shrink holes in phosphoric iron is very common. They result from the shrinkage of the metal in passing from the liquid to the solid state, exceeding the expansion resulting from the separation of graphite, plus the solid contraction of the casting as a whole. The fluid eutectic sinks away by gravity to keep the lower part of the mould filled. Where they occur they weaken the casting as well as increase its porosity.

There is a further effect on the strength of castings to be considered. Even in cases where silicon and carbon contents are low, and phosphorus is relatively high, the effect of the element is exerted through the whole mass, lowering the melting point and prolonging the solidification period. Wherever this occurs, from whatever cause, the weakening effects resulting from the development of internal stresses caused by the slower cooling of thicker parts are accentuated, as also are those resulting from the presence of hard cores. The greater fall of temperature before solidification is complete inevitably means greater contraction, and the semi-solid metal is weak, and stresses or fracture will result.

In the light of these considerations the disputes so often raised as to the advantage or otherwise of feeding castings, and providing risers, will be intelligible. What would yield a better result in one case may fail to do so in another when the metal has a different composition. It can only provide against fluid contraction, the liquid pressure of the head forcing the liquid to follow every phase of the solidification and maintain the mould full. In the absence of such pressure any gas that separates may form films on the developing solid and

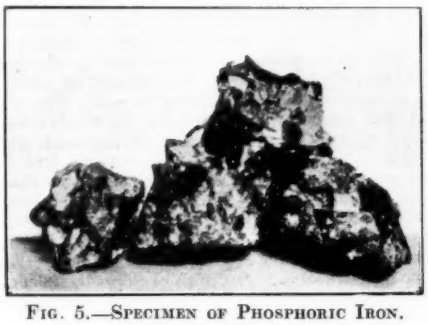


FIG. 5.—SPECIMEN OF PHOSPHORIC IRON.

prevent the perfect cohesion of the mass. In worse cases it may form bubbles and occur as blow-holes.

For thin castings of uniform section where solidification is completed rapidly, the ill-effects of phosphorus do not appear, and the improvements noted in castings where the use of chilling plates is resorted to are due to the prevention of such separation as will make the structure coarsely granular by the separation of the components.

The effect of the chilling plates is to cause the solidification in that region to proceed with such rapidity that it is completed while the metal in the head is sufficiently fluid to follow the contraction and feed the casting. When used, smaller heads are necessary. The retention of some of the constituents—*e.g.*, carbon—in the solution acts directly as a means of increasing the strength.

These chilling plates act by causing the removal of heat to be more rapid from parts that would otherwise remain hot, and either serve as feeders for thinner parts at a lower level in the mould, or which would become graphitised by slow cooling.

An example of the former action is to be found in the large 9.5-in. bombs. The unsoundness and weakness at the junction of the cylindrical part A, Fig. 6, have been very disastrous to many makers. The unsoundness has been entirely due to eutectic formation and its attendant troubles.

By lowering the phosphorus in this particular casting to from 0.3 to 0.5 per cent., according to the amount of other components, this has been completely remedied without the use of chilling plates.

It is unnecessary to deal with weakness arising from crystallisation in directions that intersect each other—say at right angles. This is generally attributed to the confusion arising from particles being acted on by two forces at right angles to each other at the moment of deposition. There is another and more potent cause. The metal where the intersection occurs is always less sound, whether cooling be slow or very rapid. With slow cooling the withdrawal of the eutectic is responsible. This accounts for porosity, sweating without running, under the hydraulic test, under flanges in heavy castings where eutectic-forming irons are employed, and its arrest by the use of reasonable chilling plates. With chilling, the increased shrinkage resulting from the absence of graphite separation causes a lack of metal at the point where solidification is longest delayed.

It also accounts for the weakness in certain white irons of similar section. An example showing actual separation at the line of intersection is shown.

Various fractures in castings during cooling may be traced to the same cause—*e.g.*, cracks occurring at the junctions of the sides and bottom of cylindrical vessels with flat bottom, as Fig 7. Cast in the position shown it will be seen that the lines of weakness should appear at A. The eutectic would fall away into the sides, and weakness, if not actual unsoundness, would result. The unequal contraction of the sides and bottom in cooling is responsible for the cracking or weakening that occurs. If such a casting were used for any chemical process, or be subjected to alternations of temperature, cracking and rapid attack are

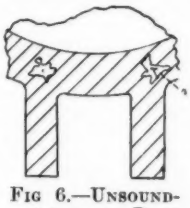


FIG 6.—UNSOUNDNESS IN BOMB CASTINGS RESULTING FROM EUTECTIC FORMATION.

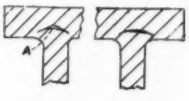


FIG 7.—UNSOUNDNESS DUE TO THE PHOSPHIDE EUTECTIC AND POSITION WHEN CASTING.

bound to follow the use of one so weakened. The trouble with the phosphoric eutectic is the fact that it does not prevent but rather favours, under ordinary conditions and with the irons generally employed for foundry purposes, the separation of large graphite flakes which form partings and sliding surfaces.

The author has found crack-like fissures following the graphite plates in cases of corrosion where actual porosity was visible under the microscope, such cracks being connected with minute cavities which formed a chain leading to larger cavities which occurred in the middle of the thickness. The cracks occurred on each side of the graphite flake, and were lined with corroded metal, the flake itself occupying the middle position. The metal examined was not entirely corroded, but formed part of a casting that had failed through corrosion. It was therefore possible to follow these points with certainty.

Manganese.—The effects of this element may be thus summarised:—It lowers the melting point to a small extent and increases the fluidity of the metal. Being a metallic element, its behaviour is different from those considered. It resembles iron and forms carbides, sulphides, silicides, phosphides, etc., in the same way. These compounds are, however, more stable at high temperatures than the corresponding iron compounds. Its distribution and mode of existence in the metal vary. It may exist as part of any iron formation so long as saturation be not reached. It is accordingly found associated with the carbide, the silico-ferrite, and as sulphide. Hatfield found that the carbide from an iron containing 2.66 per cent. manganese contained 3.74 per cent. of Mn, showing that it had entered the carbide in greater proportion than existed in the original iron, indicating the greater stability of the carbide containing manganese. The iron contained only 0.85 per cent. of silicon, and no reference is made to graphite. It was presumably a white iron. Arnold and Read have shown that the same applies to steel below the saturation point.

XUM

Manganese decomposes both sulphide and oxide of iron. The familiar "break" on molten iron is much more pronounced in iron containing manganese, probably due to elimination of gas and the convection currents arising from the increased density of the upper and cooler layer. When cast under proper conditions of temperature the increased soundness and freedom from blow holes is thus explained.

Manganiferous irons usually contain more carbon. Thus spiegel and ferro-manganese contain from 6 to 7 per cent. This increase is due to the presence of the manganese, and the whole of the carbon is in combination as carbide. Its presence in foundry irons *under similar conditions* has the same effect. This has been the author's repeated experience, of which two examples are given:—

(1) Gr., 2.65; C.c., 0.31; Si., 3.27; Mn., 1.64; P., 1.58; S., 0.09.

(2) Gr., 3.2; C.c., 0.13; Si., 2.96; Mn., 0.29; P., 1.4; S., 0.11.

Despite the higher silicon and lower sulphur contents the combined carbon is much higher. The manganese is the only element responsible for the difference.

Not only is the tendency to retain carbon greater, but the pearlite formed is much more finely laminated. This confirms in cast-iron what was pointed out by Coe in the series of manganese, iron, carbon alloys (white-iron series). Coe shows it to be due to the lowering of the pearlitic change point, which in grey iron is rapidly lowered. With 4 per cent. of manganese it was not observed at as low a temperature as 350 deg. C.

The author has invariably found that the hardness increases, and ascribes the effect largely to the increase of combined carbon. Some of the increase is due to the manganese remaining in solution in the silico-ferrite. The tensile strength and elasticity are increased, and the iron machines with a fine smooth surface, and may be readily glazed. West's figures tend to show that its effects are greatest in high silicon iron where the presence of that element would tend to lead to the graphitisation of the metal most readily. With more than 2 per cent. of manganese the hardness increases rapidly.

Sulphur.—This element occurs principally as sulphides of iron and manganese. Its effect on the strength depends on the manner in which it exists, and on its behaviour with regard to other components.

It has in some way the effect of preventing the separation and decomposition of the carbide, but at the same time lowering the solubility of the carbide. Sulphur added to molten cast-iron causes it to throw up a sooty coating. This carbonaceous matter is the product of displaced carbide. The sooty material contains also sulphide of manganese.

This displacement of carbide prevents or reduces the possibility of graphitisation, and this increases the probability of whiter and drawn castings. The pasty stage is prolonged, and all the troubles arising from contraction during this stage are accentuated. The exact form in which the sulphur is taken up is now under investigation in the author's laboratory, and some progress has been made.

The retention of a larger proportion of combined carbon makes the metal harder and more brittle. It does not follow that the tensile or transverse strength of the metal is reduced if soundness be attained, but this is difficult, and drawn castings are inevitable if much be present.

This applies only to the sulphides remaining in solution or as double compounds in the metal. Pure iron free from silicon and manganese can retain sulphides equal to 0.8 per cent., *i.e.*, nearly 2 per cent. of sulphide of iron. If the sulphides be thrown out of solution and segregated from the metal the effect is minimised as in Fig. 4.

Manganese has the effect of causing this segregation. It consequently exerts a dual effect. Its addition to sulphury irons renders the metal softer and reduces the tendency to draw and the troubles resulting from these causes. The amount necessary to produce this effect varies with other components. In ordinary grey-irons the amount varies from 0.5 to 0.7 per cent., the larger quantities being required in the harder irons containing less silicon; the danger of the hardness being increased by the added manganese applies only when the amount is excessive.

The sulphide of manganese, or the mixed sulphides of manganese and iron, separate more readily, and form small blobs or crystals, as seen in the figure.

Very small additions of sulphur produce serious changes in the metal for making soft castings, and the effect of silicon is rapidly neutralised. Many of the vagaries occurring in practice in connection with the addition of silicon are due to this being overlooked. The increase in the sulphur contents of the metal during melting is most responsible. This, in turn, depends on the sulphur in the coke and the temperature of melting. Metal melted hot and rapidly, takes up less sulphur than when melted at lower temperatures and slowly.

The increased porosity of castings in iron containing sulphur appears to be due either to the greater solubility of gases when in the molten state, which are given out on cooling, or to the fact that the metal cannot retain as much when in the solid state as is usually present.

The diminution in the amount of graphite liberated accounts for the greater tendency to produce warped, drawn, and unreliable castings, and also at the same time for the increase in strength sometimes noted with a small increase of sulphur. The sulphide to produce this effect must remain in solution in the metal, and the effect may be neutralised by the presence of manganese.

THE ANNUAL REPORT OF THE BIRMINGHAM BRANCH OF THE INSTITUTION OF BRITISH FOUNDRYMEN.—Mr. F. B. Holberry, the Hon. Secretary, in presenting the annual report, stated that the Council considered that the past session had been successful, although not so successful as had been hoped. The meetings had been transferred back to the Technical School owing to the high cost of the room at the Chamber of Commerce. Seven lectures had been held, all on Saturday evenings, and the attendances had been up to the average. The Council, however, would like to emphasise the fact that much larger attendances were necessary if the Birmingham Branch was to be the premier branch of the Institution. Six out of the seven lectures had been given by members of the Branch, and the Council thought that the discussions had been as good, helpful and interesting as any in the history of the Branch. No visits to works had been possible this year owing to the fact that many works had been on short time through the serious depression of trade, but it was hoped that the outlook would soon brighten and that they would have some highly successful visits during the next session. The dinner was very successful. Owing to the increase of the subscription, several members had resigned, whilst a revision of the membership list had resulted in the removal of eight others for non-payment of subscription. Thanks to the addition of 26 new members, they closed the session with a total of 200, an advance of six on last session. The membership was made up as follows:—Members, 40; associate members, 119; associates, 37; honorary members, 4. The subscription arrears on December 31, 1919, stood at £28 13s. due from 38 members, but some of these arrears had since been cleared off. The Council regretted to report that only a small percentage of the members were paying the levy to the Delegate Fund. They appealed to all members to pay this levy with their subscriptions. The officers and Council looked forward with hope and confidence to the coming session, and desired to make it the most successful in the history of the Branch. They would be exceedingly glad to receive offers of papers or lectures for the next session.

AN AMERICAN FOUNDRY CLOSED.—The West Virginia Malleable Iron Company, Point Pleasant, W. Va., suspended operations April 14, when the moulders rejected the proposal of the management to cut wages 10 per cent. Officials of the company state that the works will be closed indefinitely, and will be operated as an open shop when reopened.

The Constitution and Properties of Gunmetal.

In a lecture recently delivered to the Birmingham Local Section of the Institute of Metals, Mr. R. T. Rolfe, of Bedford, referred to the derivation of the name of this alloy, from the fact that bronzes, containing generally from 8 to 11 per cent. of tin, but sometimes less, were formerly employed in the construction of cannon. Except for the fact that a little zinc was now added as a deoxidiser, gunmetal of the same composition was still in common use. The alloy, however, was still more ancient; relics of the bronze age in Britain were of very much the same composition as modern Admiralty gunmetal.

In modern times the term gunmetal was generally used to denote the alloy of 88 per cent. copper and 2 per cent. zinc. The Admiralty specification allowed a maximum of 2 per cent., and the Air Board specification a maximum of 2.5 per cent. of zinc, and the latter specification was a little more severe with regard to physical tests, although there was no difficulty in meeting it with metal of fairly good composition. Lead in the Admiralty specification was not to exceed 0.5 per cent., whilst the Air Board prohibited lead. The restriction in the proportion of lead was doubtfully necessary, and was possibly of far less moment than the proportion of, say, antimony. The restriction to 10 or 12 per cent. of tin was necessary, because the ductility of alloys rich in tin was very low, whilst up to 12 per cent. of tin there was considerable choice of alloys suitable for general casting purposes and of varying mechanical qualities. Some of his own results showed that with a progressive decrease in the tin and increase in the zinc there was a progressive slight decrease in the yield point and maximum stress figures, accompanied by an increase in ductility, due to the decrease in the proportion of the hard and brittle Delta constituent. For certain purposes—for example, for bearings, for discs for high-lift pumps, and for similar purposes—the Admiralty alloy was the most suitable. For general castings, where special hardness was not requisite, the cheaper mixtures might often be substituted with great advantage.

The usual structure of gunmetal represented a metastable condition, and only required one of two things, either a sufficiently slow rate of cooling down after casting, or a re-annealing, to transform to its stable state by the absorption of the Delta constituent. It therefore followed that variation in the cooling conditions played an enormous part in altering the structure and the mechanical qualities of the alloy. It was, for example, by no means uncommon to find in large castings that the structure was entirely Alpha solid solution. Small castings showed the usual typical structure.

As to the effect of casting temperature, a considerable amount of attention had been paid to this question by different investigators, notably Karr and Rawdon, Carpenter and Elam, and various others. There was no doubt that the best results in casting this alloy were obtained by pouring within the limits of a so-called "safety range," which was, as determined by Karr and Rawdon, between 1,270 deg. and 1,120 deg. C. These figures were substantially confirmed by Carpenter and Elam. His own suggestion was that in making large castings the top limit of 1,270 deg. C. should not be exceeded, whilst for small castings one could safely pour at a temperature rather higher, say a little over 1,300 deg. C. The lower limit of 1,120 deg. C. might be rated a little too high, as in his own experiments he obtained no falling off till the metal had cooled down to about 1,060 deg. C.

Dealing with the effect of re-melting, the lecturer quoted the figures of Karr and Rawdon, and pointed out that the evidence was very conflicting. Perhaps the most complete experiments had been those made by C. P. Karr for the United States Bureau of Standards, the results of which were given in a paper read before the American Institute of Mining and Metallurgical Engineers in 1919. In these results, with chill-cast metal, there was a marked falling off in strength with continued melting, the virgin metal giving the highest values. In the specimens cast in sand no marked effect due to re-melting could be observed. This, Karr explained, might possibly be due to the maintenance of a low pouring temperature, it being well known in foundry practice that Government bronze (the American name for the 88 : 10 : 2 alloy) tended to deteriorate after two or three meltings. These results were not very conclusive wih regard to re-melting, except in the pronounced deterioration of the chill-cast metal. The opinion expressed by Karr did not march very well with the results of another investigator, as given in "The Brass World," results obtained from the first and second melts of an Admiralty gunmetal of normal composition. From these results it would appear that re-melting increased both the strength and the ductility of sand castings. It was stated that analyses of the test bars after the various meltings showed that the composition had not altered in the least—which appeared a little surprising—whilst the improvement in properties was ascribed to the elimination of blowholes and the production of a fine-grained structure by re-melting.

As to the effect of antimony and arsenic, he stated in a paper last year that the effect of re-melting on the antimonial series was slightly to decrease the strength and slightly to increase the ductility of the sand castings, whilst being apparently negligible with the chill castings. In the arsenical series, the effect in the case of the sand castings varied with the proportion of arsenic, whilst there was a slight falling off in the strength and ductility of the chill castings. In a similar research on the effect of lead in gunmetal, the results of which he hoped to publish shortly, the re-melts of the sand castings showed in each case an increase in the strength and ductility, whilst with the chill castings the effect was negligible. The results as a whole were so variable that further work required to be done before the question could be considered as definitely settled.

As to the effect of impurities, in very many cases the supposed effect of any particular impurity was rather conjectural, and frequently there was no very definite evidence on record to support the popularly accepted opinion. There was thus need for much further work in the matter.

Aluminium oxidised in melting to alumina, which it was difficult to skim off, giving rise to films of this oxide between the crystal grains of the solidified alloy. It increased the amount of liquid contraction—*i.e.*, shrinkage—and, according to Johnson, was also responsible for a greater resistance on the part of the alloy to absorption of the Delta constituent on annealing.

Antimony added in ½ per cent. steps up to 1½ per cent. hardened the alloy, causing a progressive falling off in the strength and the ductility. Antimony also caused unsoundness in both sand and chill castings. It had no noticeable effect on the microstructure of chill castings. One of the most interesting effects of arsenic in sand castings was on the microstructure, and was in the direction of increasing the proportions of secondary Alpha and of eutectoid. Bismuth functioned as it did in copper, giving rise to brittle intercrystalline films, and was therefore most objectionable in even the smallest proportions. It was not likely to occur in any appreciable quantity in gunmetal.

Iron was stated to give rise to hard spots, which, according to Dewrance and Primrose, were those of a tin-iron compound. This, of course, was not necessarily the only explanation, as in the case of contamination of gunmetal borings by iron borings the iron particles might simply not be melted. Gulick had stated that iron increased the strength and decreased the ductility of gunmetal; whilst, according to Johnson, it increased the strength without any loss of ductility. It was therefore probable that iron was a prejudicial impurity. There was, however, need for much further work on its precise effects.

The effects of lead had been the subject of much controversy, quite apart from such contentious matters as those of shock-resistance and resistance to corrosion. The effect of lead in improving the machinability was well known. An advantage was claimed by Dewrance for gunmetal containing ½ per cent. of lead over lead-free gunmetal for

use at temperatures up to 550 deg. C. This was disputed. With regard to the mechanical qualities of leaded gunmetal, the progressive addition of lead, according to Primrose, led to a steady decrease in strength and ductility.

The lecturer had lately carried out work on the influence of lead, on the same lines as in the case of his antimony and arsenic investigation, and had obtained results quite different from those obtained by Primrose. It appeared that in sand castings up to a certain point, say 1½ per cent., lead slightly increased the strength and very much increased the ductility of gunmetal, whilst it was only on exceeding this figure that any falling away in strength or ductility occurred. Again, it was quite possible to have 2 or 3 per cent. of lead in gunmetal, and yet have a margin over the minimum figures of the Admiralty physical test specification. Therefore, it was quite clear that the prejudicial results of lead had been exaggerated.

Manganese, according to Gulick, acted as a deoxidiser, increasing the soundness and strength of the alloy, whilst reducing the ductility a little.

Nickel was stated to give rise to unsoundness, owing to the liberation of gases during solidification. Arnott suggested that by using a rich nickel-copper alloy, thoroughly deoxidised by magnesium, this trouble would be avoided and the true effect of the nickel could then be ascertained.

Phosphorus as a deoxidiser might be added with advantage, but only in small quantities.

Silicon had been employed in place of phosphorus as a deoxidiser for gunmetal. According to Guillet's work, the effect of silicon was not beneficial. The precise effect of this impurity, as with that of many others, needed more exact investigation. Sulphur, when it reached 0.39 per cent., gave a very brittle metal.

The heat treatment of Admiralty gunmetal was originally investigated in 1913 by Messrs. H. S. and J. S. G. Primrose, who demonstrated that quenching between the temperatures of 500 and 700 deg. C. led to a progressive falling away in strength and ductility; whilst at 800 deg. C. there was a slight improvement, giving about the same results as at 600 deg. C. On the other hand, annealing considerably increased the ductility and also the strength on account of the removal of the eutectoid from the microstructure, leaving only the crystals of the Alpha solid solution. The temperature found by these two experimenters to give the best result was 700 deg. C., both in dry sand and in chill castings. Very long continued annealing produced a slight diminution in strength and ductility.

In a later note by H. S. Primrose results on dry sand casting were quoted, showing that no material improvement could be expected by annealing at 250 deg. C., whilst there was also no sensible absorption of the eutectoid. The lecturer found the same results in his own experiments.

This noteworthy discovery of the improvement capable of being brought about by annealing had not resulted in the process being brought into standard industrial use. Several reasons might be given for this, the chief being that by proper control of materials a satisfactory margin of physical results over specification could always be obtained without recourse to annealing. There was also the fear, possibly not warranted, that treatment at a temperature of about 700 deg. C. would cause large castings to sag. Finally, it must be remembered that for many purposes annealing would cause a falling-off rather than an improvement in properties, and there was possibly on the part of many people an inability to discern for what purposes annealing could profitably be employed, and when it would render the material useless for the intended purpose. Annealing at 700 deg. C. on an alloy of normal composition resulted in a homogeneous solid solution with marked oxidation at the boundaries, and this, of course, was associated with very unsatisfactory mechanical qualities.

As to the effect of heat treatment, the investigations of Dewrance and of Longbottom and Campion showed that when gunmetal was subjected to a temperature exceeding a point somewhere between 175 deg. and 200 deg. C., there was a sudden falling away in strength and ductility. The maximum stress, about 13 tons, at the ordinary temperature, remained practically constant up to 200 deg. C., and then fell off, almost reaching zero at about 750 deg. C. It was thus evident that Admiralty gunmetal was not suitable for employment at any temperatures much above the normal. The improvement in heat-resisting power afforded by lead claimed by Dewrance had been disputed.

The effect of superheated steam could not be judged by reference to tests made at the particular temperatures at which the gunmetal was to be used, because the action of superheated steam was not merely a question of temperature, but also one of chemical action. With many alloys, tested at the temperatures obtaining with superheated steam, say 400 to 600 deg. F., quite good results would be obtained; whilst if the same materials were actually subjected to the action of the steam for a period, they would probably become quite rotten, giving, of course, extremely low results whether tested hot or cold. Quite apart from this, it was obvious that in the case of Admiralty gunmetal, in which the strength could be seriously reduced merely by heating to the particular temperature, assuming this to be at least higher than 400 deg. F., there were serious objections to the use of such metal for any purpose involving contact with superheated steam. With a high degree of superheat, say 600 deg. F., the strength of gunmetal was reduced considerably quite apart from any special action of the steam.

Electric Core Ovens.

According to Mr. Wirt S. Scott, manager industrial heating section, supply department, Westinghouse Electric and Manufacturing Company, the company recently undertook the work of investigating the baking of cores electrically, carrying out this research work along lines of investigation made in connection with other baking processes which now have become standards for many industrial plants. Tests were run, extending over a period of six months, during which time cores of various mixtures were baked, with varying amounts of ventilation and at different temperatures. The core-baking oven was operated on standard production work, but test pieces were placed in the oven along with the work, at different points. At the end of each bake, the work was thoroughly examined as to its conditions, and the test pieces subjected to crushing load and tensile strength tests. The conclusion of these tests resulted in very strong recommendations being made by the process and materials department of the Westinghouse Company for the adoption of electric heating in their brass foundry, with the result that the electric oven, which was purchased on an experimental order, has been taken over by the works and is now in every-day operation. The advantages claimed are:—(1) Cores are from 100 to 200 per cent. stronger than those dried in an ordinary gas-heated oven. (2) They are uniformly baked, due to the fact that electric heaters may be in the oven at suitable points to give the proper heat distribution. (3) Rejected cores are eliminated, due to the thorough and uniform baking. In some American foundries the rejects amount to 40 per cent., and a 30 per cent. rejection is a common occurrence. (4) Automatic temperature control removes the human element to a large extent from the baking operation, and assures the cores being baked at a definite and predetermined temperature. (5) Ventilation regulated to the desired amount by means of a motor-driven exhauster.

SHANGHAI MINT.—The Shanghai Mint will be under the control and direction of the Ministry of Finance and the Currency Bureau, and the staff, including a foreign assayer, will be appointed by these Boards. The appointments, which will be in the nature of permanent positions, will be in recognition of special qualifications. The reports of the assayer are also to be published from time to time. Bullion sycee and the Tael standard will be ultimately abolished, and although the Mint will have a producing capacity of $1,000,000 a day, at first it will only coin $12,000,000 a month.

Auxiliary Oil Firing in the Cupola.

According to a Paper recently read by Herr Karl K. Berthold, of Vienna, before the Austrian branch of the Association of German Engineers in that city, some experiments were made with auxiliary oil-firing in a cupola in order to reduce the consumption of coke, just now a very expensive commodity in Austria.

The cupola was an ordinary one, 800 mm. (32 in.) in diameter inside, with four tuyeres and a working pressure of 350 to 400 mm. (14 to 16 in.) water gauge. The normal charge has been about 400 kg. (880 lbs.) for some years. After a preliminary trial the weight of bed coke was reduced to 510 kg. (1,122 lbs.)—as against the usual 550 kg. (1,210 lbs.)—and the coke in the charge was reduced to 550 kg. (1,210 lbs.) by diminishing the depth of the individual layers. The coke consumption in much soot, it was decided to use three burners in the next dozen trials. These results are also shown in Table I. They show a marked improvement. The coke consumption was greatly reduced in most of them.

One great advantage of the auxiliary oil-firing was that it was possible to reduce the sulphur in the iron from 0.14 to 0.07 per cent., and thereby improve the machinability of the castings. Austrian foundries are obliged to use Upper Silesian coke with abormally high sulphur content.

Another advantage was that with oil-firing the temperature could be easily controlled, and could, if required, be more quickly changed than with exclusive coke firing, as the fuel was introduced at the bottom and not from the top. Moreover, the cost of melting was also reduced from 14,850 to 9,925 Austrian crowns per day (exchange at par 24 crowns to the £1).

Use of oil-fuel reduces also the ash, and, consequently, the quantity of slag—another important consideration.

Table I.—Showing the Results Obtained from the Use of Auxiliary Oil-firing in Cupola Practice.

Trial No. 1.	Total throughout.	Bed coke.	Charge coke.	Coke consumption per 100 kg. of iron melted.	Charge coke per 100 kg. of iron melted.	Total oil consumption.	Oil consumption per 100 kg. of iron melted.	Hourly melting.
	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.	Kg.
1	8,400	510	550	12.6	6.6	81	0.96	4,060
2	6,600	540	537	16.3	8.1	—	—	3,190
3	5,800	570	320	15.3	5.5	61	1.05	4,190
4	10,400	580	780	12.9	7.5	28	0.27	3,460
5	8,800	540	605	13.0	6.8	63	0.71	3,640
6	9,400	540	535	11.4	5.69	71	0.75	3,420
7	9,600	540	540	11.2	5.62	68	0.7	3,530
8	9,600	540	910	15.1	9.5	—	—	3,110
9	10,600	540	545	10.2	5.14	58	0.55	3,580
10	9,000	540	420	10.7	4.7	50	0.52	3,530
11	13,000	540	360	10.46	4.19	114	1.32	3,410
12	12,000	500	470	8.08	3.91	146	1.21	3,600
13	11,200	500	560	9.47	5.0	134	1.2	4,310
14	13,200	540	650	9.02	4.9	121	0.92	4,310
15	8,400	500	430	11.1	5.1	73	0.93	4,090
17	8,600	500	360	10.0	4.2	124	1.44	3,970
18	12,450	500	510	8.11	4.1	108	0.86	4,030
19	14,000	540	500	7.85	4.0	104	0.74	4,420
20	13,100	540	420	7.32	3.26	99	0.75	4,250

Trials 1 to 8 inclusive with two burners. Trials 9 to 20 inclusive with three burners.

Trial No. 1 was thus reduced to 12.6 per cent. of the molten iron, of which 6.6 per cent. represented the weight of the charge coke. The oil-fuel consumption amounted to 81 kg. (178 lbs.) for the whole melting (8,400 kg.—8 tons 2 qrs.), or about 0.96 per cent. of the molten iron. The temperature of the iron in this first trial was satisfactory for ordinary machinery castings, but not so satisfactory for thin castings. In the first eight trials only two burners were used.

The second trial was made without oil fuel. The weight of the bed coke was somewhat increased (540 kg.—1,188 lbs.), but the charge coke was less (537 kg.—1,181 lbs.) than in the first trial, which is explained by the fact that the whole output of iron was less (6,600 kg.—6 tons 9 cwts). The whole coke consumption was 16.3 per cent., of which 8.1 per cent. was the charge coke, the material having been carefully picked.

All the next five trials (Nos. 3 to 7) were with auxiliary oil firing. The data for these and all the other trials are shown in Table I. The coke consumption in Trial No. 3 was not so good, owing to the small charge put through. It should be mentioned that in the case of the first three trials the arrangements for supplying compressed air were somewhat defective. Owing to the want of a proper compressor, the compressed air was in these three cases supplied from cylinders. A small compressor was pressed into service on the fourth day (Trial No. 4), which eventually gave trouble, necessitating stopping the oil firing and finishing with coke alone.

In both Trials Nos. 6 and 7 the molten iron was hot enough for producing thin castings. Trial No. 8 was again carried out without oil-fuel.

Notwithstanding the comparatively good results of the first eight trials, these were not considered wholly satisfactory, and as it was impossible to increase the quantity of oil-fuel without making

Core Bench with Vibrator Attachment.

A light, all steel coremaker's bench with vibrator attachment developed by the Malleable Iron Fittings Company is described in a recent issue of the American "Foundry." The bench is rigidly constructed and is supported upon a reinforced table which may be bolted to the floor. It is strongly and rigidly built. The distinctive feature of the bench is that a rectangular space in the centre is taken up by a stiff plate having a vibrator attached directly to the bottom actuated by bearing down on the plate. In this way any small core box may be rammed on the plate, and by setting the vibrator in motion before lifting the box a clean draw is assured.

In connection with the conference on June 30 and July 1 on the "Means of Increasing the Thermal Efficiency of Heat Power Plants," organised by the Institution of Mechanical Engineers, an exhibition will be held of appliances connected with boiler-room economy and with the efficient use of steam and internal combustion engines.

Mr. R. B. McColl, the general manager of the locomotive works of Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited, Newcastle, will shortly vacate his appointment at the Scotswood works. In addition to having been in full control of the locomotive department, Mr. McColl was also local director and general manager of the gas, oil engine and the pneumatic tool departments.

XUM

The Casting of Metals.—Part II.*

(*Continued from Page* 436.)

By Thos. Turner, A.R.S.M.

Head of Metal.—Perhaps the best-known device to ensure "dense metal" is the provision of a casting head of sufficient height and thickness. As there is an idea that the density of the metal is increased by the pressure of such a head, a few words on this subject may not be out of place. Let it be assumed, for example, that the height of the head of metal is 2 ft. Now, a height of 2 ft. of water will give a pressure of about 1 lb. per sq. in.; 2 ft. of fluid aluminium alloy would therefore give a pressure of about 3 lbs. to the sq. in., and 2 ft. of brass or iron about 7 lbs. Now, suppose a large casting has a surface of 5 ft. square in a horizontal plane, this would give 3,600 sq. in., and with fluid brass or cast iron the hydrostatic upward pressure would amount to something like 25,000 lbs., or, say, 11 tons. The total hydrostatic pressure would therefore be considerable, and unless the upper box were well weighted it would lift, and the casting would be spoiled. Such facts are the probable cause for the idea that a good casting head exerts considerable pressure upon the metal, and thus leads to increased density. It is true that metals, like gases, may be made more dense by pressure. The compressibility of solids, including certain metals and alloys, has been experimentally studied by Adams, Williamson and Johnston, who obtained results of considerable scientific value when using pressure up to about 12,000 atmospheres, or nearly 90 tons per sq. in. But the effect of a pressure of 7 lbs. to the sq. in. upon a bar of metal would result in so small an alteration of length as to be quite negligible; and some other explanation must be sought than that of any increased density of the metal itself. The good effect observed is due to two principal causes. Firstly, the hot metal in the head is in fluid contact with the whole of the interior of the casting during the process of solidification, and thus supplies metal to fill up the spaces due to fluid contraction. Secondly, just as a very moderate pressure inside a soda-water bottle is sufficient to prevent the escape of the gas in the form of bubbles, so the relatively small pressure of the fluid head of metal prevents the escape of gas in the form of blowholes. Blowholes are not formed in the solid, but in solidifying metals. The net result of pressure, therefore, is that while the density of the actual metal remained the same, the density of the casting may be considerably increased, owing to the absence of intercrystalline and other spaces.

Casting Temperature.—It has long been known that there is a range of temperature within which the most satisfactory results are obtained when casting any particular metal or alloy. It is only in recent years that quantitative values have been given to these temperatures. Dealing with pure metals only, silver affords a familiar example of the effect of high temperatures in pouring, as the metal is less sound, and does not roll properly if too hot when casting.

A. McWilliam and P. Longmuir have shown that better results are obtained, when casting either zinc or aluminium, if an intermediate temperature is employed, than when higher or lower heat is used. The value which gave the best result in their experiments for zinc was about 528 deg. C., and for aluminium 691 deg. C.

An illustration of the effect of improper casting temperature could also be taken from the casting of chilled cast-iron rolls, in which case if the heat of pouring is insufficient a number of small blowholes or pin-holes appear in the upper part of the roll. In such cases it is always safer to use a high temperature, though excessive heat is to be avoided.

Superheat.—In dealing with casting temperatures it is usual to refer to the temperature of the metal in the ladle, and not to that in the mould. Obviously the latter is the important factor, but the former is the more easy to ascertain or to modify. In practice it is usual to employ bare base metal thermocouples and direct reading galvanometers, in order to determine the temperature of the metal before pouring. Some excess heat must be supplied, above that required to just melt the metal, if it is to flow in a stream from the ladle and run to the most distant part of the mould. It is not possible to fix a definite amount of superheat, such as 100 deg. C., and apply it in all cases. Metals with a high melting point will obviously lose heat more quickly when being poured than those which are more fusible. The weight of metal, its specific heat, the rate of pouring, and the size of casting, all have to be taken into account. A rough approximation may be made by taking a percentage of the difference between the ordinary temperature and the melting point of the metal, and adding this percentage in order to obtain a suitable ladle temperature.

In taking the density of a series of alloys of aluminium and zinc, the author has endeavoured to obtain comparative results by casting each alloy at 5 per cent. above the liquidus. Thus if the alloy melted at 600 deg. C. it would be poured at 630 deg., and with the particular series very good results were so obtained. On this system lead would be poured at about 345 deg. C., copper at 1,140 deg. C., and a mild steel, melting at 1,450 deg., would be poured at about 1,525 deg. In practice a higher superheat is found to be necessary in some cases, owing to pouring and moulding conditions, and as much as 20 per cent. superheat will not be too much. When dealing with pure metal all that is necessary is that the mould shall be filled with metal at such a temperature, and supplied at such a rate and in such a manner that any entrapped air bubbles, or gas from the mould, may be able to escape before the mass solidifies. Any excess temperature, above that which is necessary to ensure the desired result, not merely leads to waste of heat, but may also give inferior mechanical properties in the castings.

Gases in Metals.—The fact that castings so frequently contain hollow cavities, or "blowholes," has naturally led to considerable attention being paid to the relationships which exist between gases in metal under widely varying conditions. Molten steel, for example, may retain many times its own volume of gas, chiefly hydrogen and carbon monoxide, and may give off a considerable proportion of these while cooling from the pouring temperature in an ingot mould. The non-ferrous metals as a class do not dissolve such large volumes of gas, and behave in more varied ways towards gases with change of temperature. The study of gases in metals may be considered under three heads:—

(*a*) The metal may absorb gas at a low temperature, and give it out again when the temperature is raised. The occlusion of hydrogen by palladium, or the absorption of hydrogen by steel during immersion in certain acids, are examples of this action. Steel may become embrittled to a remarkable extent by absorption of hydrogen in the cold state; but on heating the metal to a suitable moderate temperature the gas is evolved and the steel reverts to its original condition, apparently uninjured, despite the remarkable internal changes which have taken place.

(*b*) The gas may result from reactions which occur within the metal while it is in process of solidification, or after it has been solidified. By a reaction, for example, between oxide and sulphide of copper, sulphur dioxide may be evolved, and it is impossible to cast a sound ingot of copper from a sample of metal in which this reaction is in process. In the same way steel is rendered unsound by reactions between carbon and oxide of iron present together in the fluid bath. Another example of deterioration by gas reaction is that of the effect produced by hydrogen upon copper containing cuprous oxide, whereby the "pitch" of the metal is destroyed and brittleness results. The unsoundness of castings made from scrap metal is largely due to gas produced by reaction: though trouble also arises from oxide and from infusible combinations. From the metal caster's point of view gas of reaction presents the greatest difficulty, and the only remedies are (1) to com-

* Extracted from the May Lecture delivered before the Institute of Metals on May 4.

plete the reaction, either by sufficiently long melting and stirring, or by the addition of a suitable chemical agent; or (2) to add some material which will assist the metal to absorb the gases.

(c) The gas may be dissolved in metal, much as air dissolves in water. All ordinary water contains more or less air in solution, and for many purposes its effect is so slight as to pass unnoticed. Yet we are familiar with the fact that on heating water, or reducing the pressure, bubbles of gas appear; and the air which is present in the water not only has a profound influence on animal and vegetable life, but also on metallurgical operations. Thus dissolved oxygen plays an important part in the cyanide process of gold extraction, and in the deposition of hydrated ferric oxide from waters which contain iron in solution.

It appears to be clear that the solubility of hydrogen in copper and in nickel at constant pressure increases with rise of temperature to the melting point, then suddenly increases again, and afterwards steadily rises with the temperature. On the other hand, hydrogen is very slightly soluble in molten zinc; 100 grms. of zinc dissolves about 4.8 mg. of hydrogen at 300 deg. C., but the solubility decreases as the temperature rises, so that only 1.3 mg. is in solution at 750 deg. C. Carbon monoxide is slightly soluble in copper and brass, but carbon dioxide is practically insoluble. Hydrogen dissolves in 70: 30 brass to a marked extent between 500 deg. and 900 deg. C., and the greater portion of such hydrogen is retained on cooling. Sulphur dioxide is absorbed with reaction by heated brass, but does not lead to unsound castings, provided the metal has been properly melted and poured.

The presence of any of the common gases, either in the atmosphere in which the metal is melted, or in the metal itself, does not necessarily lead to blowholes or porosity in the ingot, provided that the metal is well melted and poured at a suitable temperature and in a proper manner. This conclusion, though negative, is of considerable practical importance, since it indicates that the first essential to success in metal casting is proper melting and a suitable pouring temperature, and that the influence of dissolved gases, or of the gases in the furnace, though at one time much feared, has become, in the light of further investigation, of much less relative importance.

Casting Temperature of Alloys.—In some experiments conducted in the author's laboratory by J. H. Teng, in 1918, preliminary tests were made in order to determine the superheat suitable for casting a series of aluminium-zinc alloys. The metals used were commercially pure aluminium, presented by the British Aluminium Company, Limited, and redistilled spelter, presented by Messrs. Stewarts & Lloyds, Limited. The aluminium contained 0.32 per cent. of iron and 0.28 per cent. of silicon; while the zinc only contained 0.10 per cent. of cadmium, 0.07 of lead, and 0.02 of iron.

From these metals an alloy containing 90.3 per cent. of aluminium was prepared and cast, in a warm iron mould, into round bars 1 in. in diameter. Table III. shows the casting temperature, tensile strength, and elongation.

TABLE III.—*The Influence of Casting Temperature on 90: 10 Aluminium Zinc Alloy.*

Casting Temperature Degrees C.	Maximum Stress. Tons per Sq. In.	Elongation per cent. on 2 Inches.
736	7.45	15
704	7.43	13½
672	8.00	17½

The temperatures chosen were respectively 15, 10, and 5 per cent. above the liquidus of this alloy, and the result arrived at was that 672 deg. C., or a superheat of 5 per cent., was sufficient in this case, and that it gave better results than a higher temperature. It may be noted that E. Carey Hill states that when melting aluminium, or its commonly used light alloys, there is no need to heat above 700 deg.-720 deg. C. for the production of sand castings, and that with excessive heating unsatisfactory castings result. For aluminium this would be equal to a superheat of about 7.5 per cent., which is no doubt sufficient for sand-cast aluminium.

The earliest accurate observations on the casting temperature of copper alloys with which the author is acquainted are those of P. Longmuir, who showed, in a series of experiments over thirty in number, on an alloy in which the composition remained constant and the only variation was casting temperature, that the tenacity in tons per square inch varied from a minimum of 12.5 to a maximum of 26.2, while the extension per cent. on 6 in. varied from 5 to 51.6. It was pointed out that, with industrial bronzes, pouring at a low heat tended to produce central piping in the runner heads, to the production of cavities in the thicker parts of the casting, and to the formation of what are sometimes wrongly called "hot cracks," especially at the junction of thick and thin metal.

In connection with the production of castings for high pressures, H. C. H. Carpenter and C. A. Edwards refer to the importance of a proper temperature and rate of cooling in the production of castings free from blowholes. In a copper-aluminium alloy containing 91 per cent. of copper, a pouring temperature of 1,125 deg. C. was found to be satisfactory. This is 80 deg. above the freezing point of this alloy. Elsewhere it is recommended that the casting temperature should be not more than 50 deg. to 80 deg. above that at which freezing begins. This would correspond with a superheat of some 4.8 to 7.6 per cent.

With Admiralty bronze the recent researches of H. C. H. Carpenter and C. F. Elam have shown the importance of correct pouring temperature in preventing blowholes and porosity, and it is suggested that a temperature of about 1,200 deg. C. is suitable for this alloy, since overheating to 1,400 deg. produces porosity, while unsoundness frequently results from pouring below 1,100 deg. Shaw and Edgar recommend that in order to produce sound valve castings in Admiralty gun-metal the alloy should be heated to 1,315 deg. C. and poured at 1,260 deg.

Brass of 70: 30 composition begins to solidify at about 925 deg. C., and T. G. Bamford and W. E. Ballard came to the conclusion that cooling the metal to within 40 deg. of the liquidus, or to about 965 deg., will certainly ruin the mechanical properties of high-grade brass which has been melted under ordinary furnace conditions. This is equivalent to a superheat of 4.3 per cent. They also suggested that when casting tubes a higher temperature was necessary than when casting solid ingots, and that for tubes of 70: 29: 1 composition it is not advisable to go below 1,150 deg. This corresponds with a superheat of 24 per cent.

P. Longmuir concluded that yellow brass should be cast at about 1,020 deg. C. and Muntz metal at 973 deg. C., and pointed out that low mechanical tests were obtained if the pouring temperature were too high, and unsatisfactory castings if it were too low. This is in each case a superheat of about 11 per cent.

Contraction and Shrinkage.—In considering the volume changes which take place while the hot fluid metal passes into the cold solid casting two words are employed which originally have practically the same meaning, namely, "contraction" and "shrinkage." Unfortunately those who have written on this subject have not always used the words in the same sense. The term "shrinkage" was introduced about thirty-five years ago, by J. W. Keep, who was the inventor of a system of testing which is generally known to foundrymen as "Keep's test." The author has always followed Mr. Keep in applying the term "shrinkage" to the proportional difference between the length of a casting and that of the mould in which it was produced. In other words, it is the net contraction from the moment when solidification begins in the mould. In Keep's standard test a ½-in. square bar is cast in sand, between iron yokes which are exactly 12 in. apart. The cold bar is afterwards placed in the yoke between which it was cast, and a graduated wedge is inserted so as to measure the distance between the end of the bar and the yoke. This distance is the shrinkage. The term "contraction" is restricted to that portion of the diminution in volume which occurs while the cooling metal is still fluid. To make the difference more clear it is sometimes referred to as "liquid contraction."

Institution of British Foundrymen.

SHEFFIELD BRANCH.

At a meeting held at the Cutlers' Hall, Sheffield, on April 15, the Branch-President (Mr. J. R. Hyde) in the chair, the officers for the ensuing year were elected. Mr. John Watson, the senior vice-president, was elected president. Other elections were as under:—Vice-Presidents, Mr. W. J. Dawson, Dr. T. Swinden, and Mr. J. Shaw; three members of Council, Dr. Desch, Mr. Ambrose Firth, junr., and Mr. H. Bradley; auditors, Mr. G. Gummer and Mr. A. L. Steggles; secretary, Mr. W. A. Macdonald; assistant secretary, Mr. J. F. Kayser. The retiring president thanked the Council and officers for the painstaking way in which they had supported him during the past year.

Meeting Competition against Castings.

DR. F. ROGERS delivered a lecture on this subject, remarking, in opening, that he wished to talk about castings from the point of view of the technical competition of other materials that were evolved in the brains of engineers and metallurgists, with the view of giving better quality and perhaps, sometimes, cheaper material. A hundred years ago there were practically only two structural materials that they need consider—wrought iron and cast iron. In those days the tendency was to supersede wood or stone by cast iron, and to supersede cast iron by wrought iron. Rolling and forging were then very costly. They generally regarded that time as being about the date when railways were born, but that was not strictly correct, because rails had existed for two centuries before that. The first were probably forged wrought-iron strips. These were followed by cast-iron plates, and later by wrought-iron plates, but until early in the nineteenth century cast-iron rails held the field. Wrought-iron rails were first rolled about 1820, and they gradually ousted the cast-iron rail altogether, and were themselves ultimately succeeded by steel. This example of railway development was typical of engineering progress throughout, and illustrated the actual competition between cast iron and wrought iron.

What were the circumstances which controlled competition against castings, causing something else to be considered as a substitute for them or an improvement on them? Castings were well recognised as being the least expensive way of producing many articles of more or less complex form. In a great many cases there was nothing so cheap as the cast-iron job, and no more direct and rapid means of production. In a great many of these instances, again, there was no competition in price. That had been so for a long time, and in a broad sense it was still so to-day. Next, therefore, they had to consider quality and special properties, and it was there that competition was fundamentally important. What, then, were the properties generally of castings, in which the competing materials beat them to such a degree as to be actually worth a higher price—in many cases a substantially higher price? From the starting point of cast iron versus wrought iron, the prime difference was in regard to toughness. This was the outstanding feature of wrought iron, whereas by comparison

TABLE I.—*Showing Comparative Tests of Materials.*

	Tensile strength. Tons.	Elong. Per cent.	Brinell Hardness No.	Impact.
Cast-iron	10 to 20	2	100-160	0
Malleable cast iron	18 to 26	10-20	100-140	2-10
Mild steel forging	24 to 30	20-30	100-130	5-30
Mild steel castings	24 to 36	15-25	100-180	5-20

brittleness was the outstanding quality of cast-iron, again speaking broadly. They could readily appreciate that it was this enormous difference in respect of toughness which led to the evolution of malleable cast iron, which developed into a keen competitor with ordinary castings, and which had had to fight for its existence against drop forging and other competitors. In due course steel castings also entered into the struggle. The earlier crucible steel castings were frequently harder than present-day steel castings until they were annealed, but generally the toughness of steel castings was regarded as greater than that of malleable cast iron and less than that of wrought-iron or steel forgings, which might alternatively be used.

The accompanying figures would afford a comparison of the materials They were only typical in a general way, and special instances should not here be considered, such as alloy steels, exceptional heat-treatments, articles of exceptional forms, and many other factors which were well understood to influence test results.

Next to toughness, to the practical man there always occurred the question of the perfect soundness of any casting, a question which practically vanished when they came to material which had been forged or otherwise worked. The two principal types of unsoundness in castings which had had to be overcome by great patience and vigilance were (1) pipe and shrinkage cavities, and (2) blowholes. A third, namely, dirt in some form, logically came into line here, but there was not so much trouble from that source as from the first-mentioned, which to-day probably constituted the greatest source of defects with which the founder had to cope. Worked material was recognised in general to be more uniformly tough than cast material. On this account it was possible to design more closely in forgings than in castings, and in other words to cut down weight in many directions where a casting was to be replaced by worked material. The saving in weight, therefore, in many instances entered as a most important factor into the competitive question. A saving in weight in almost any part of a machine, but especially in a moving part (and in a motor car or railway rolling stock every part in this sense was a moving part), was of far-reaching effect upon the design, frequently enabling a reduction in weight to be made in other parts of the machine, the stresses in which depended upon the weights of the neighbouring parts. A substantial all-round reduction in weight might lead to great evolution of the machine, *e.g.*, to increased speeds in production machinery, motor cars or aeroplanes, increased lifting power of aeroplanes, and, throughout, a possible reduction of cost of the machine.

Clearly, the important point to the founder was to evolve his craft to the end that weights might be reduced by designers with confidence. In regard to the thicker parts of castings, this simply meant the embodiment in the casting of those general virtues which they were always endeavouring to secure. In regard to the thinnest sections, however, although much had been done—especially in the course of the evolution of air-cooled motor cylinders, for instance—yet it appeared to him that the founder could still open out new fields as he continued to give the designer greater confidence in specifying thin sections in castings where hitherto only sheet metal, or stampings or drop forgings, had appeared to be practicable.

Here founders had made progress by die-castings, and by some of the attempts at centrifugal casting and other methods of casting under increased pressure. Much good work had been done in producing castings with both thick and thin sections in the same casting, and there he found it more natural to admire the founder's efforts than to preach him a sermon.

There had been many wonderful attempts to oust castings by machining from the solid, and as an example he exhibited an air-cooled cylinder machined from the solid forged steel bar. There was an instance where, during quite recent years, castings lost a field which had been their own, and which had been one of their most wonderful achievements, for the casting of the fins of an air-cooled cylinder, achieved over 20 years ago, was one of the first steps forward into thin work in engineering that was successfully accomplished in cast-iron foundries. Cycle hubs offered a field for progress in this direction.

There were many ways of making a built-up job instead of a casting. It was curious, but he had observed lately that even a large number of the more modern domestic mangles were being made out of bent tube, with steel-cast corners and fittings, very much like a bedstead. The weight of the ironwork was probably 30 per cent. less than that of the ordinary all-cast mangle. The type in which a machine was built up by an engineering

fitting from numerous pieces, instead of having a single casting, only occurred now in a few specialities, he thought, where an enormous amount of accurate work was wanted and could be done on repetition lines. It occurred, for example, in chain pulley blocks.

The question as to whether casting or building-up would be the better proposition could only be decided by long trial. If in a motor car, for instance, the cutting down of weight was really of fundamental importance, then it would only be in a comparatively small number of cases that castings could hold their own. He believed it was the case that, when alloy steel was introduced into the construction of the Ford motor car, the weight of the whole car was cut down directly by 30 per cent. At first, of course, the cost went up by about 500 per cent., but that was very soon cut down below the original figure, not only by direct saving in weight but also by mass production.

In regard to built-up parts, an important case to consider was that in which the building up was done by welding. There they had an important competitor to castings in many instances, because the welding was often much less expensive than building up by engineering fitting. Tanks for holding large volumes of liquids furnished an example of this. At the weld, they had practically the properties of the casting again. Of course the weld generally set the limit to the qualities of the welded tube. That was very interesting, and the founder should keep it well before him when he was considering this question of the competition of the two on quality.

In the non-ferrous metals they were not confronted with such an enormous degree of brittleness as they had in ordinary cast iron, and therefore many of his remarks would not apply directly to such things as aluminium and brass. In regard to actual strength there was much less likelihood of the castings being superseded by highly superior materials. The ultimate competitor was very often a very high-grade alloy steel, and there, on quality of course, the casting was a very different proposition indeed from the alloy steel forged part or machined part. The cast-steel motor-lorry wheel had had a very serious competitor in the built-up wire wheel. This was an interesting case in which they had first a steel casting—which was admitted to be an advance, in both quality and cost, on an iron casting—superseded ultimately by a high-grade steel, though not necessarily an alloy steel. The saving in weight there was obvious, and was clearly the primary object of the more costly construction. They could perhaps hardly see the same thing in the case of chilled cast-iron railway wheels. They were not so much used in this country, although they were still used and manufactured here, but they were extremely important in the United States. In this country the standard wheel for all wagon work had for a long time been that of wrought iron, and to-day we went on to the rolled-steel wheel, which would no doubt ultimately supersede them all.

After what he had said, some of them might be wondering what was going to happen to the foundry. Were castings to go to the dogs, and to be entirely superseded? This, he did not suggest. But there would be this continual competition from other kinds of material, and castings would have, as it were, to shift their ground; founders would have to look elsewhere for their outlets at times, and they would always find them. There would always undoubtedly be an enormous field for cast iron. During the war, in a few instances, heavy machine beds were constructed of concrete or ferro-concrete, and probably that would continue to be done, but clearly the great majority of machine tools would continue to use cast-iron frames, bedplates, etc. Bedplates formed a very important aspect in the competition of materials against one another. The bedplate of a machine or an engine was undoubtedly, generally, a very clumsy article. The designer could easily design a structural-steel bedplate that would be strong enough in the ordinary sense, and very much lighter, but he would find, if he tried to use anything but fairly heavy castings, that the bedplate or frame would not be stiff enough for its job. It might be strong enough to stand all the stresses without breaking, but if it lacked stiffness the result would be vibration, and strains on the fundamental parts. On a motor car, the only thing that supported the crank shaft was a comparatively flimsy case made of aluminium, quite a thin section. True, it was a casting, but there was no virtue in that, as it was a soft metal. Its only virtue was in its shape. It was spread out in a way that gave it a very important degree of stiffness, but it was quite fair to wonder if that stiffness was sufficient. He could say with entire confidence that in many cases it was not—that the crank case was not doing its duty as a bedplate, not supporting the crank shaft to the extent that was necessary. In his own experience, crank shafts had broken on that account—not because the bedplate or the crank case had broken, but simply because it was too flimsy. In Sheffield the problem of cast-tools arose from time to time, and probably they would hear more of it. Attempts were made to cast them solid to form. In the war a great number were used, which had been cast out of alloy steels—not necessarily high-speed steel only—and it was probable that the only problem in connection with them was to get a fairly good casting. The question of casting a material which would cut was easily solved in many alloys; the only other question was that of getting a casting which was fair to shape and so on, so that no great amount of expensive machining was required. That was the founder's problem.

Discussion.

MR. H. DARLEY, in opening the discussion, said some years ago he had the idea that there was some risk of castings being largely displaced by drop forgings and different methods of building up. But he had altered his opinion considerably. To-day the art of founding was, to his mind, more scientific than ever it had been before. Excellent methods of repetition moulding for large quantities had been developed. Providing a casting is homogeneous and solid (if made in cast-steel) he considered it was possible to make one that would stand up to almost anything that a forging of the same weight would do. Armour cast to shape had given very good results during the war, and that surely was a sufficient proof of what can be done with castings. But the difficulty with castings was that there was at times some degree of mystery about them, as obviously it was impossible to say what was inside them. Still, there are such methods of testing so that it can be reasonably asserted that they are perfectly reliable. Incidentally, the cost of dies for drop forgings was more that that of patterns for the foundry.

ENGINEER-COMMANDER JACKSON said he was of opinion that all their troubles in the foundry, in respect to blow-holes, originated in the furnace in the melting process. During the war, the submarine was gradually evolved from a small boat to a formidable-sized vessel. They got up to twelve engines and found that the three after cranks took more torque on them than the other cranks, and consequently put the engine out of tune. To overcome that, it was necessary either to re-design the whole structure of the engine or else design a crankshaft of a different material, that would stand up to the torque. The Admiralty designed a crankshaft of the nickel-chrome steel variety. They had trouble with oil tanks—great difficulty in keeping them oiltight. That was overcome by electrically welding the joints all the way along the seams. With regard to steel castings, he quite agreed with Mr. Darley. The degree of accuracy now obtained would be rather an eye-opener to people who were not in touch with them every day. Steel castings for rolling stock were now practically up to within a thirty-second of an inch, and their bearing parts were not machined in a great many instances.

MR. J. FERDINAND KAYSER, Assoc. Met., said that when considering the question of castings versus forgings the majority of foundrymen considered only the relative physical properties of forged or cast material, and there was a great tendency to imagine that the only reason that a casting was not suitable for a particular purpose was that its properties were not sufficiently good. In many cases, however, such a view was quite untenable.

At the present time the majority of cams on large gas engines were made from drop forgings, and the only reason that castings were not used, though castings were in the rough cheaper than drop forgings, was that the best castings generally

had such a poor surface that machining was a matter of considerable difficulty, and that the finished cam made from cast material was more expensive than that machined from the drop forging.

The same trouble was also experienced in the case of aeroplane cylinders. At the present time few new aeroplanes are being made with air-cooled cylinders, and most cylinders are casting propositions. The forgings at present used are, however, so much easier to machine than castings that cast cylinders are practically unknown. He (Mr. Kayser) had devoted a considerable amount of time to the question of obtaining good surfaces, and as far as experience went he had only been able to surmount the difficulty by very great modifications of the metal, and had been able to make practically no marked improvement by simply modifying the sand.

Mr. Hyde said Dr. Rogers had mentioned that the non-ferrous industry had a set-off against the machinist in the die-casting process. He believed that many iron and steel founders had attempted to find some method of die-casting whereby they might gain a little in the same direction. The case of the chilled-cast iron railway wheel was one in which partial die-casting was a success in cast iron, and a tremendous tonnage was made in America. Of course the wheel was not as good as the steel wheel, as used in England, and it had not gained in favour here since the Government brought them over five years ago. In connection with the substitution of structural steel, girders and channels were made from the softest material, and he believed they could hardly put any stress upon them without getting some deformation. Cast iron, on the other hand, did not move at all until it broke. The point as to the saving of weight was no doubt a very important one, but he thought considerable progress was being made in the manufacture of thin steel castings, and perhaps they might be able to hold their own.

Dr. Rogers, in reply, remarked that drop forgings were often in an extremely crystallised condition, and he wondered whether they might not sometimes be called die-castings. From that point of view, they sometimes were very nearly die-castings. Perhaps the material was unsuitable for die-casting in that particular sense—certainly it had not been treated suitably; it might be that some subsequent treatment could partly correct the troubles. Within the elastic limit in every case, cast iron would deform elastically more than steel for the same load or stress, but the elastic limits of the two might be regarded as roughly comparable, so that, in order to get only equal elastic deformation of a cast bed-plate and a steel bed-plate, the dimensions of the two must be comparable. In any part where stiffness mattered, they must not attempt to get it by simply cutting down dimensions. It might be done by a redesign of the form entirely, but they must not attempt to get it with the same form by cutting down the section only, because that would lead to flimsiness or springiness, which was usually a curse.

Gazette.

The Anglo-Russian Engineering Company, Limited, London E.C. Mr. W. A. J. Osborne, 119, Finsbury Pavement, E.C., was appointed receiver April 27.

Messrs. G. Hands and J. T. Broughton, stampers and piercers, 146, Hockley Hill, Birmingham trading under the style of G. Hands & Company, have dissolved partnership.

Messrs. F. W. Brierley, J. Sugden, A. D. Wickham and A. Taylor, electrical engineers, trading under the style of J. K. Cotton & Company, 2, Water Street, Rochdale, have dissolved partnership.

Messrs. Hy. Meikle Lees and Hugh Nimmo Mackay, trading as Hy. M. Lees & Company, 24, Oswald Street, Glasgow, machinery merchants, have dissolved partnership. Debts by H. M. Lees, who continues the business

The partnership heretofore subsisting between Messrs. J. Evans and W. Gray, trading in the style of the Southern General Engineering and Acetylene Welding Company, 137, Arundel Street, Landport, engineers, has been dissolved.

Messrs. Alf. Whyld and Theodore Vincent Dean, trading as the Reliable Welding Company, 310, Radford Road, Nottingham, acetylene welders and fire bar manufacturers, have dissolved partnership. Debts by Mr. T .V. Dean, of 300, Radford Road, Nottingham.

Messrs. Geo. Davidson Gillender, Thos. Gillender, and Thos. Wilkinson, trading as the Northern Brass Foundry Company, Glasshouse Lane, East Street, Gateshead, brassfounders, have dissolved partnership. Debts by G. D. and T. Gillender, who continue the business.

Thomas & Isaac Bradley, Limited. A petition for winding up this company was presented, April 27, by Moss Isaacs, Limited, 122, Cannon Street, E.C., iron, steel, and metal merchants. Hearing, County Court, Dudley, May 24. Messrs. Vallance & Company, 28, Bishopsgate, E.C., solicitors.

In the Chancery Division, on the 6th inst., counsel moved for the appointment of a receiver of the business of W. S. Laycock, Limited, Victoria Works, Sheffield, on behalf of holders of guaranteed debenture stock issued in June, 1919. Counsel said the security had become enforceable, as the company had threatened to cease to carry on business, and the trustees had appointed a receiver and manager. He intimated that the plaintiffs would be willing that the defendants' receiver should be appointed receiver under the motion. His Lordship allowed the case to stand over for defendants to decide whether they agreed to that course. If they agreed, the case need not be again mentioned.

Company News.

Shotts Iron Company, Limited. — Interim ordinary dividend passed.

Dorman, Long & Company, Limited.—Interim ordinary dividend, 2½ per cent., free of tax, for half-year.

Siemens Brothers & Company, Limited.—Final dividend, 1s. per share, making 10 per cent. (free of tax) for year.

British Thomson-Houston Company, Limited. — Profit, £470,470; brought forward, £208,431; depreciations, reserves, etc., £210,000; ordinary dividend, 6 per cent.; carry forward, £225,892.

Alley & Maclellan, Limited.—Net profit, £41,047; brought forward, £7,315; depreciation, £23,091; writing off goodwill of Gartside factory, £14,000; dividend, 6 per cent. per annum; carry forward, £5,449.

Blake Boiler, Wagon & Engineering Company, Limited.—Profit, £11,907; brought forward, £3,759; total, £15,666; depreciation, £2,798; ordinary dividend, 10 per cent. for year, less tax; reserve £4,000; carried forward, £3,770.

Andrew Knowles & Sons, Limited.—Credit balance, £69,653; brought forward, £19,267; less interim dividend (3 per cent.) paid, £22,500; disposable balance, £66,420; final dividend, 4 per cent. (making 7 per cent for period); carried forward, £36,420.

Brown Brothers, Limited.—Profit, £60,047; brought forward, £28,947; reserve, £4,628 and £5,372; reserve for sundry investments, £2,500; ordinary dividend, 7½ per cent. (2½ per cent. paid), tax free, and bonus, 2½ per cent., tax free; carry forward, £31,119.

Irvine's Shipbuilding & Dry Docks Company, Limited.—Profit, £215,715; amortisation, depreciation, etc., £19,945; E.P.D., etc., £85,000; final dividend on preference, 1s. per share, less tax; ordinary dividend, 8 2-11d. per share, less tax; carried forward, £13,687.

Bell's United Asbestos Company, Limited. — Profit, £64,670; brought forward, £26,046; interim dividends, 6 per cent. preference, £1,800; 5 per cent. on ordinary, £10,977; final preference, £1,800; final ordinary dividend, 1s. 6d. per share, making 12½ per cent. for year; depreciation, £20,000; carried forward, £34,124.

Iron Trades Employers' Insurance Company, Limited.—Premium income, £1,174,769; total receipts, £1,236,496; compensation and incidental expenses, £600,465; balance of revenue account, £546,975; reserve, £61,727; investments reserve, £55,000; staff fund, £8,000; special hospital donations, £5,000; return of premium, 25 per cent.

Vaughan & Dymond, Limited.—Capital £10,000 in £1 shares, to take over the business carried on by C. J. Dymond and W. A. Vaughan, at Milburn House, Newcastle, and at North and South Shields, as Vaughan & Dymond, and to carry on the business of consulting, structural, mechanical, electric, and general engineers. Registered office: Milburn House, Dean Street, Newcastle.

The late Mr. Oliver Winder, of Sheffield, formerly of Wood Green House, Wednesbury, engineer, left £9,820; net personalty, £9,716.

Mr. F. E. Pratten, late director of J. & E. Hall, Limited, of Dartford, has joined the firm of Messrs. W. H. Pease & Company, engineers and merchants, 8, Southampton Row, W.C.1, and in future the company will trade as W. H. Pease, Pratten & Company.

Trade Talk.

ABERCARN STEELWORKS, Monmouthshire, which have been idle since the end of last year, have been restarted.

THE strike at Messrs. Ward's yard at Briton Ferry and Swansea has been settled, the men accepting a reduction of 12½ per cent.

MESSRS. CRAIG, TAYLOR & COMPANY'S shipyard, Stockton, closed down last week, throwing a further thousand men out of employment.

THE CLYDESDALE IRON AND STEEL WORKS, which have been partially in operation since the commencement of the strike, have been closed down.

THE HURD COALCUTTER & ENGINEERING COMPANY, LIMITED, have removed to their new works at 47, Haggs Road, Pollokshields, Glasgow.

THE GRANGE IRON COMPANY, LIMITED, Durham, has received a £50,000 contract from the Sheffield Corporation for cinder working and house refuse screening plant.

THE boilermakers on strike at four shipyards at Walker-on-Tyne on the question of the reduction of rates of pay decided, at a mass meeting held recently, to resume work at once.

THE DANISH STATE RAILWAYS have concluded a contract with Belgian works for the supply of 7,400 tons of rails. This is the first large order given by Denmark to Belgium since 1914.

THE works of Messrs. Smith, Patterson & Company, Limited, Pioneer Foundry Blaydon, have been closed until further notice, owing to the industrial crisis. Between 300 and 400 hands are usually employed.

AN agreement has been arrived at between the Master Wireworkers' Association (London) and the men's union for a reduction in wages taking effect immediately owing to the decreased cost of living.

AT a well-attended meeting of the Sheffield Society of Model and Experimental Engineers, Mr. Fletcher, of London, gave an address on "Electro-Deposition of Metals." Mr. A. Bayliss, A.M.I.M.E., was in the chair.

ALL boilermakers, ironworkers, shipwrights, and blacksmiths in Leith shipbuilding yards, have gone on strike, having refused to accept the reduction of 3s. weekly for time workers, and 7½ per cent. for piece-workers.

THE directors of the Staveley Coal and Iron Company state they cannot reopen the blast furnaces unless costs of production are reduced to meet foreign competition, and to this reduction collieries must contribute their share.

THE works of Messrs. Vickers at Barrow, which employ 15,000 hands, will close this week unless further supplies of coal are available. The town is mainly dependent on the works, the weekly wage bill being close on £100,000.

THE ELECTRIC LOCOMOTION COMPANY, Globe Chambers, 19, The Side, Newcastle-upon-Tyne, are being converted into a limited liability concern under the style of the Electric Locomotion and Foundry Company, Limited.

IT is reported that a contract for forty-five third-class carriage under-frames and bogies required for new passenger rolling stock of the North-Western (State) Railway of India has been awarded to the Clayton Wagon Company, Limited.

THE INSTITUTION OF CIVIL ENGINEERS have completed arrangements to continue this year the series of conferences which were interrupted by the rebuilding of the institution premises and the war. The conferences will be held on June 29 and 30 and July 1.

AN agreement has been signed by the Railway Companies and the three Railway Trade Unions that, upon de-control, joint councils of officials and employees shall be formed to deal with administrative and labour questions on the principles of the Whitley Report.

MR. FARRELL, President of the United States Steel Corporation, addressing the Foreign Trade Convention, declared that the United States Government had sustained a loss of $800,000,000 through not selling its merchant fleet to foreigners when the armistice was signed.

THE result of the ballot of the members of the North-East Coast Shipyard Trade Unions on the proposed wage reductions of about six shillings per week was issued on Tuesday, the figures being:—In favour of reduction, 45,169; against reduction, 35,913; majority in favour, 9,256.

LICENCES under the Non-Ferrous Metal Industry Act, 1918, have been granted to the undermentioned companies:—Harrison & Company, Limited, Granger, 85, Gracechurch Street, London, E.C.3; Kaye, Harry, 12, Fenchurch Avenue, London, E.C.3; Lazarus, Sons & Lewis, 10 and 11, Lime Street, London, E.C.3.

THE BIRTLEY IRON COMPANY, Birtley, Co. Durham, have ensured supplies of pig-iron and coke which will enable them to keep their foundries at work during any prolongation of the coal strike. The company can put in hand any class of work which may be urgently required for a reasonably quick delivery.

"THE strained industrial circumstances are reflected in the financial position of some of the unions affiliated to the Federation," says the quarterly report of the General Federation of Trade Unions. "In no previous crisis have there been so many applications for assistance not contemplated or provided for in the rules."

THE ARIZONA COPPER COMPANY officially announces that in view of the accumulation of stocks and the general conditions of the copper market, the directors have discontinued operations for the present. The largest producers in America have already adopted this course. The Arizona mine is almost wholly owned by Scottish shareholders.

IN reply to a question in the House of Commons, Mr. Baldwin said the authoritative statement that Germany to-day can put a ton of steel in England at a price £5 cheaper than it costs in England to make it, appears to have been substantially correct for a recent date. The position has, however, now been affected by the operation of the Reparation (Recovery) Act.

REPLYING to a deputation from the National Union of Manufacturers, Dr. Macnamara, Minister of Labour, made it clear that he had no intention of abandoning the promotion of Trade Boards in industries where it was, in his judgment, essential that they should be set up, but he stated that he would use the greatest discretion and forethought before promoting further boards.

IT is reported that a French chemist named Basset has invented a process which reduces the amount of coal necessary for the manufacture of steel by more than a half. Slack coal and slow burning coal which France possesses in large quantities, has been submitted in the new process for the metallurgic coke hitherto indispensable, and which had to be almost entirely imported.

MESSRS. CAMMELL LAIRD & COMPANY, LIMITED, at Birkenhead, on the 9th inst., launched the twin-screw geared turbine steamer "Gouverneur-General Chanzy," which they are building to the order of Le Commission Aux Transport Maritime et a la Marine Marchande for mail, passenger, and cargo service between Marseilles and Algiers. The vessel is 378 ft. long, and will have a speed of nineteen knots.

It is interesting to learn that the steel production in Czecho Slovakia for 1920 amounted to 972,976 tons, including 163,663 tons or 16.82 per cent. of Bessemer and Thomas steel, 792,794 tons or 81.48 per cent. of Martin steel, and 16,519 tons or 1.70 per cent. of electric steel. In comparison with 1919, when the output amounted to 786,022 tons, the production has increased by 186,954 tons, or 23.8 per cent.

FOUNDED in 1871, the Newcastle and District Association of Foremen Engineers and Draughtsmen is now in its jubilee year. Reference to this fact was made at the half-yearly meeting of the Association held at Newcastle. Evidence of the growth of the work of this body can be gauged from the fact that in the first year of its existence the membership was between 20 and 30, whereas now it stands at over 500.

IT is intimated by the Board of Conciliation for the regulation of wages in the pig-iron trade of Scotland that as a result of the auditors' investigation it has been ascertained that the average realised price of all classes of Scotch pig-iron for the three months ended March 31 last was £11 9s. 1d. According to the sliding scale, this represents a reduction in blast-furnacemen's wages of 42 per cent. on basis rates for the three months from the beginning of May current.

AN agreement has been arrived at between the Master Wireworkers' Association (London) and the men's union for a reduction in wages taking effect immediately. The wages will be reduced for day workers by 1d. per hour, taking a datum line of the cost of living of 137 per cent. For each 12 per cent. decrease in the cost of living according to the Board of Trade returns a further reduction of ¾d. per hour will take place. Present piece-work wages are to be reduced by 5 per cent., and decreases will be made in the same proportion as day-work decreases.

IT was announced at the recent annual meeting of the Iron and Steel Institute, the President (Dr. J. E. Stead) presiding, that, under the Andrew Carnegie Research Scholarship, the Council of the Institute had awarded £100 to Dr. Leslie Aitchison (Birmingham) to assist him in carrying out an investigation of the Low Apparent Elastic Limit in quenched and work-hardened steels, with particular reference to fatigue strength proof stress and constitution. Other awards were:—Mr. C. O. Bannister (Liverpool) and Mr. F. C. Langenberg (United States), £100 each, the former to carry out research work concerning the mechanical properties and heat treatment of very low-carbon high-chromium steels, and the latter for research in impact testing; and Mr. J. N. Greenwood (Sheffield), £50, to study the question of obtaining optical data on steels and steel-making materials.

XUM

IRON AND STEEL MARKETS.

Pig-Iron.

The intervention of the holidays in the present critical position of the pig-iron industry will be a welcome relief from attendance at idle markets, in which, of late, the most pessimistic mood has invariably prevailed. That this attitude is pardonable in the circumstances is effectively demonstrated by the statistics for the iron and steel trade, which have just been issued, showing that out of over 300 furnaces in blast in the middle of last year, only 11 remained in operation at the end of April, and some of these have since gone out of action. Of every hundred persons employed in June last the industry found occupation for only 21.5 at the end of April. The production of pig-iron and steel was respectively 60,300 tons and 68,000 tons in April, as against 386,000 tons and 359,000 tons in the previous month, and 671,000 tons and 794,000 tons in April last year. In the conditions just outlined, the fact that the Cleveland iron market is almost completely neglected is scarcely surprising; indeed, the wonder is that, after such a prolonged stoppage of the coal output there should be any consumers using pig-iron.

The export trade also is absolutely idle, foreign consumers refusing to pay the price for British iron when they can purchase from other countries at lower rates. But a few small orders for Cleveland iron are still coming to hand from British buyers, and although a premium of 10s. per ton is now being asked on the official minimum for foundry qualities, a few sales were recorded. Indisputably, No. 1 Cleveland iron is now very scarce, while the available stock of No. 3 is dwindling, and as it is very improbable that many, if any, Tees-side furnaces will be blown in even if the miners come to terms, there seems a likelihood of a pronounced and continued scarcity of foundry iron. Thus even at the enhanced price it would seem a policy of prudence for those who want local iron to get it while they can. As a matter of fact, it is still much cheaper than Scotch No. 3 at 165s., even if the transport charges are added, and those who hold stocks locally are now attempting to impose conditions upon buyers that a proportion of forge iron should be taken with each delivery of No. 3. For home consumption and for export makers' minimum rates stand as follow:—No. 1 Cleveland, 125s.; No. 3 G.M.B., 120s.; No. 4 foundry, 119s.; No. 4 forge and mottled, 117s. 6d.; and white, 115s.; but the superior grades were not obtainable at the foregoing figures. No. 1 was understood to have realised 135s.; 130s. was named for No. 3; and 129s. was asked for No. 4 foundry. Movements in the East Coast hematite trade are very limited in scope, the cut of 20s. per ton having given little impetus to the demand, and although 160s. is now the nominal price of mixed numbers for home users, it is understood that 150s. would be accepted for export. In the South Staffordshire pig-iron market business continues stagnant, but as stocks in makers' yards become exhausted, prices have shown a tendency to stiffen. It was stated that the last Black Country blast furnace in operation is expected to go out of action immediately. The attendance at last Thursday's weekly market was only of very small dimensions, and transactions entirely without importance. In the West of Scotland, consumers of iron who were instituting inquiries in anticipation of the strike ending, have ceased making them. Scottish furnaces will not re-light until coal and wages are lower. In Lancashire, so far as foundry pig-iron is concerned, there is still a little business in small lots, but the prices remain very irregular. The foundry trade certainly tends to go over to the Continent in these times, and it is quite possible that some of it may not come back again, and, moreover, it is not at all certain that the foundries will be able to get orders for castings if they have to base prices on £9 per ton for common No. 3 pig-iron. A little Cleveland iron might, perhaps, be obtained at £8 delivered here, and a very little Lincolnshire at the same price; but the quantities available are very small.

Scrap.

In common with all other metal markets that for scrap continues stagnant, and at the moment there seems to be absolutely no business doing in this particular trade. A little iron and steel must necessarily be changing hands, but when manufacture ceases there is no demand for scrap. Foundry scrap, it may be noted, is getting more plentiful, while foundry pig-iron is getting scarcer, but to assume that the value of scrap will be controlled by that of pig-iron is erroneous. The current prices quoted for foundry scrap in Lancashire range from £6 to £7 per ton, according to quality, but, of course, there is no selling by which their reality can be tested. The actual price of the foundry pig-iron which yet remains on the market now ranges from £7 (in Cleveland) to £8 10s. in the Midlands, so that scrap already appears to be cheap. In the Midlands the scrap trade, both ferrous and non-ferrous, continues to exist in a state of complete stagnation, and there does not seem any prospect of any revival whatever until the present labour troubles have been overcome. Dealers have already been compelled to accumulate very large stocks, because in many cases they have contracted to keep works clear of their make of scrap material, and are not anxious to add to these stocks even at the present low prices, while consumers are entirely off the market.

Steel.

The complete suspension of fuel supplies during the strike period has had the inevitable and expected result of entirely checking manufacturing activities in every branch of the great steel industry, and although a few Sheffield firms have with difficulty managed to keep a limited number of departments going, it must be a considerable time before they are in a position to resume production after the holidays. The prevailing labour disturbance, though perhaps the chief contributory factor in the position of the industry at the moment, is by no means the only element having this effect, stagnation arising quite as much from the high prices now quoted for home steel products, which make it impossible to meet foreign competition. This has hitherto been mostly restricted to our recent Allies, France and Belgium, but a much more formidable rival in the shape of the German steel makers, is now busily engaged on the preparations for a vigorous campaign in this direction. Teutonic competition is being organised on the lines which have made German industry and war preparations so well understood. A series of journals devoted to individual branches of the steel trades is being published at the expense of German manufacturers, traders, and bankers, and the services of the highest authorities in the universities of Germany are being drawn upon, so that the publicity campaign shall lack nothing that learning and finance can afford. These publications are being distributed all over the world to likely buyers, and the whole scheme is marked by thoroughness of detail. Unfortunately for the British steel maker it is difficult to suggest an alternative policy to this aggressive form of competition, the greatest obstacles confronting producers being the exorbitant costs of fuel and labour, and until a substantial reduction in these items of manufacturing expenditure can be effected it is quite hopeless to expect an improvement in trade. The heavy steel industries are practically at a standstill. Firms like Hadfields, Hecla Works, and the Sheffield Forge and Milling Company are shut down, and Vickers, Browns, and Cammells are only carrying on a few departments. Scarcely any of the Siemens or crucible furnaces are in fire, and not since the war has the outlook been more grave, because, should the deadlock be removed, with the exchanges and other adverse effects, European markets are out of the question. The only redeeming feature is that a fair number of orders for railway materials are in hand, and small engineering tool makers are doing fairly well. In the West of Scotland the suspension of operations in the rolling mills, forges and foundries has come most unfortunately. Just prior to the strike things were beginning to look brighter, and an increasing inquiry was noticeable, chiefly on foreign account. Under present conditions the best that makers can offer is to promise delivery after the strike, and good business has thus to be turned down. Sheet bars have been reduced from £13 to £11 10s., but are still £3 to £4 higher than Continental material.

Tinplates.

Conditions in the tinplate market are no more favourable than when last reported, business continuing very quiet until some definite settlement of the labour crisis can be effected, of which at present there is no immediate prospect. In the meantime sales are being confined to stocks in makers' hands and the dock warehouses, but these resources are by no means inexhaustible, and must ultimately be entirely depleted until work at the tinplate mills is resumed. Makers are indisposed, in view of the general position, to quote forward, but a little business has been done between the rather wide range of 27s. to 30s. for the basis box, f.o.t. Light wasters, which are getting very scarce, have been in some demand, and oil wasters have been wanted, 17s. f.o.t. being asked for the latter. In other respects the tinplate market is quiet. Current rates are:—Cokes, 20 by 14, 27s. to 30s.; ditto, quarters, round 30s.; cokes, 20 by 10, 37s. to 42s.; ditto, 28 by 20, 53s. to 60s.; ternes, 28 by 20, 54s. to 55s.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.
CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

Established 1872. *Telegraphic Address: "Steel, Glasgow."*

···TRADE···
SIROCCO
···MARK···

CENTRIFUGAL FANS

For Supplying Blast to

Cupolas and Forge Fires.

Made in a large variety of sizes and suitable for pressures up to 30-in. W.G. The Fans have cast iron casings and the belt driven type are fitted with Ball Bearings.

Send for particulars to :—

DAVIDSON & CO., LTD.,
Sirocco Engineering Works, Belfast.

GEORGE JONES, Limited,

ESTABLISHED, 1803.

LIONEL STREET FOUNDRY, BIRMINGHAM.

Complete Rolling Mills for all Metals.

Machinery for Making Tubes and Wire.

MILL GEARING OF EVERY DESCRIPTION.

The American tinplate market continues very dull. If the recent price revision, putting the whole market on a basis of $6.25, has had any effect, it is scarcely discernible. Certainly nothing like the tonnage has been released by the reduction that would have been expected to come as a result of the action taken by the mills. An improved demand is expected later, but so much time has already elapsed that it is clear this tinplate season will be a very poor one. While there will be more tinplate produced and consumed than in some years, one will have to go quite a distance back to find as lean a year. The year will show a greater recession from the preceding high record than has been shown by any other year. The largest percentage recession was in 1919, 23 per cent., the next largest being 16 per cent. in 1900, while the third largest was 14 per cent. in 1913.

Finished Iron.

In South Staffordshire production has of late dwindled to minimum proportions, and with the advent of Whitsuntide works will be entirely closed, with very faint expectation of an early renewal of operations. There is practically no inquiry for finished material, because it is realised that so little is being produced. Marked bars remain unaltered, but it is generally known that the announcement of a substantial reduction is only postponed until the end of the strike, because there is no object in marking it now. Crown bars and gas strip also are stagnant and nominally unaltered, although the price quoted is considered to be rather higher than conditions will support when work is resumed again.

Metals.

Copper.—Exceptional activity was marked in last week's market for standard copper, some substantial buying being recorded each day, with values showing a consistently steady tone. Sales of three months' metals were effected at £72, and with a brisk demand values appreciated at £73, with cash also marked 10s. better, May was bought at £73 to £72 10s.; June, £72 15s., £73, and £72 5s.; July, £72 5s. to £72 10s. Refined qualities were somewhat irregular, electrolytic and wire bars at £74 to £75, both gainging 10s. in values, with strong sheets 40s. lower at £114. In the American market it is a significant fact that dealers are buyers rather than sellers and consumers who have been in the market of late find it impossible to shade 12.75c. delivered for electrolytic for May or June shipment, but some of the small producers are still taking business for prompt shipment at 12.62½c. delivered. Producers of lake copper are asking 13.00 to 13.25c. delivered for prompt and May shipment. Most of the current business is being taken on this basis. Closing prices:—Cash: Wednesday, £72; Thursday, £72 12s. 6d.; Friday, £73 2s. 6d.; Monday, closed; Tuesday, £74 2s. 6d. Three months: Wednesday, £71 5s.; Thursday, £70 15s.; Friday, £72 2s. 6d.; Monday, closed; Tuesday, £73 7s. 6d.

Tin.—Eastern cables advising sales at £184 to £185, c.i.f., business in the tin market opened firm, but later realising sales caused some reaction towards the close. Demand on consumer's account was fairly active, both in cash and three months' metal, the bulk of the buying being done at £179. May was dealt in at £179 5s.; June, £179 10s. to £180 5s. Cash Straits was done at £184, and Augnst at £186. English ingots were 10s. lower at £175 10s. to £176 10s. In the States there is a somewhat better demand from consumers than there has been recently, but as for sometime past the bulk of the business represents trading between dealers and importing interests. Closing prices:—Cash: Wednesday, £178 10s.; Thursday, £179; Friday, £178 10s.; Monday, closed; Tuesday, £181. Three months: Wednesday, £180 5s.; Thurday, £181; Friday, £178 10s.; Monday, closed; Tuesday, £182 15s.

Spelter. — Movements in this section of the metal markets have been, in the main, featureless in character, only very small offerings from the Continent coming forward at prices comparable with those ruling on this side. Belgium appears to be holding off, the higher rate of exchange operating against them, and Norway also seems to be disinclined to enter the market at the moment. Ordinary brands, prompt:—Closing prices: Wednesday, £24 7s. 6d.; Thursday, £24 7s. 6d.; Friday, £26 10s.; Monday, closed; Tuesday, £27 5s.

Lead.—The activity previously noted in the demand for this metal has been well maintained, but somewhat free profit taking had a weakening effect upon values, near dates for good soft pig declining about 22s. 6d. to £23 15s. to £23 7s. 6d. June was sold at £23 17s. 6d.; July, £23 12s. 6d. to £23 7s. 6d.; September, £23 10s. and £23 7s. 6d.; and October at £23. English closed lower at £24 15s.

Personal.

Sir W. G. Armstrong, Whitworth & Company, Limited, have invited the Crown Prince of Japan to visit their works.

Mr. G. Pepper, late of Devonshire Terrace, Bradford, retired engineer, formerly of Lister & Company, Limited, left £8,964.

Mr. T. E. Evans has retired from the directorate of the Merchant Trading Company, Limited, 275, Gresham House, Old Broad Street, London, E.C.2.

Mr. Edward Lisle, late of Oaklands, Tettenhall, Staffs., founder of the Star Engineering Company, Wolverhampton, cycle and motor manufacturers, left £49,679.

The late Mr. A. Gregory, iron and steel merchant, of George Ridley & Company, Limited, left gross estate of the value of £48,347, with net personalty £33,292.

Jones & Attwood, Limited, engineers, Stourbridge, have presented gold watches to eight of their employés who have put in twenty-five years' and more service with the firm.

Ex-Lieut. Ifor Rhys Lewis, son of Mr. and Mrs. D. Oliver Lewis, of Pontypridd, scored a notable success at the recent examination for the engineers' diploma held at the Technical College, Cardiff. Mr. Lewis headed the list of six successful candidates out of 32 competitors.

Owing to the abnormal conditions prevailing, the annual conference of the Institution of British Foundrymen, which should have been held at Manchester next month, will probably be postponed until September.

Among prominent American visitors to this country at present may be included Mr. J. A. Penton, who, after paying a visit of three days' duration to Birmingham, where he was entertained to a complimentary dinner on Thursday night by the Kindred Technical and Foundry Associations of Birmingham and district, comprising amongst others, the British Cast-Iron Research Association, the Institution of British Foundrymen (Birmingham and Coventry Branches), the Iron and Steel Institute, the Malleable Cast-Iron Association, etc.; also visited a large number of the principal factories in the district.

TENDERS.

COUNTY BOROUGH OF CROYDON.

SURREY STREET WATERWORKS.

SALE OF CORNISH PUMPING ENGINE.

NOTICE IS HEREBY GIVEN that the Council are prepared to receive offers for the taking down and removal of a large Cornish Pumping Engine now at work at the Surrey Street Waterworks, Croydon. The plant was built by the Kirkstall Forge Co. in 1868, is in good working order, and capable of pumping water at about 100,000 gallons per hour to a height of 160 feet.

For specification and permission to inspect the plant apply to the Borough Engineer, Town Hall, Croydon.

The Council do not bind themselves to accept any offer.

Offers (which will only be received subject to the conditions of sale and draft contract deposited at my office) should be sent to me by Eleven a.m. on FRIDAY, the 27th MAY, 1921, endorsed "Offer for Cornish Engine."

JOHN M. NEWNHAM,
Town Clerk.

Town Hall, Croydon,
5th May, 1921.

CASTINGS
MADE RUSTLESS

Write for Particulars.

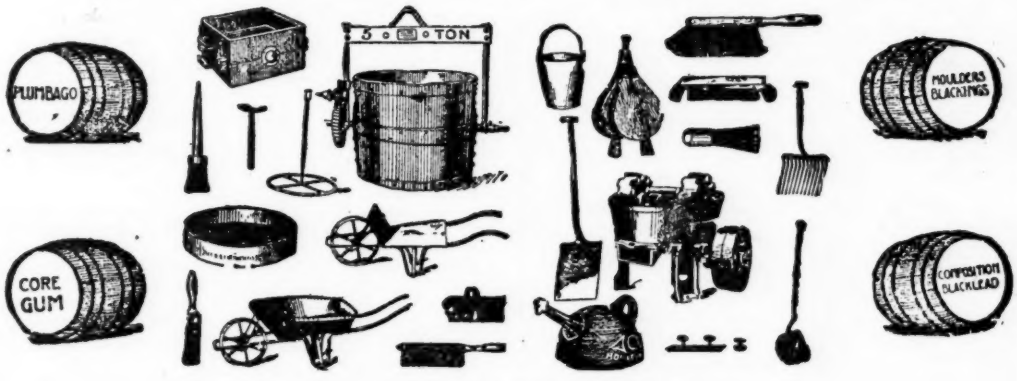
The Rustless Iron Co., Ltd.,
Trico Works,
KEIGHLEY.

Telephone: 21, Penistone. Telegrams: "Durrano, Penistone."

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



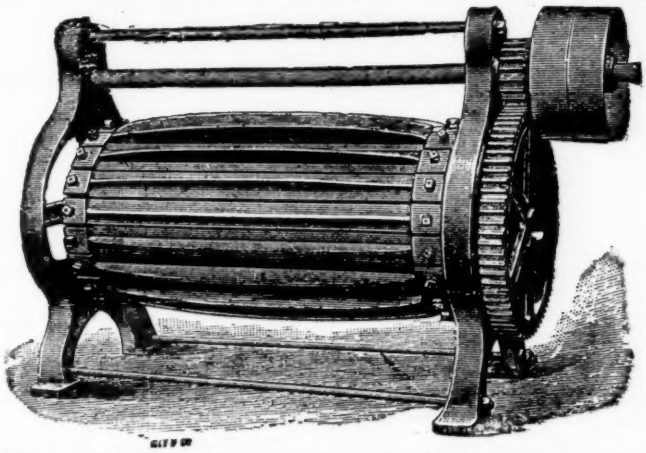
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	74	2	6
Three months	73	7	6
Electrolytic	74	10	0
Tough	74	5	0
Best selected	74	10	0
Sheets	114	0	0
India	114	0	0
Wire bars	74	10	0
Do. June	74	10	0
Do. July	74	10	0
Ingot bars	74	10	0
H.C. wire rods	82	0	0
Off. aver. cash, Apr.	69	8	11⅝
Do. 3 mths., Apr.	69	9	2⅝
Do. Settlement Apr.	69	8	6⅝
Do. Electro, Apr.	72	16	2⅜
Do. B.S., Apr.	71	6	8
Aver. spot, copper Apr.	69	7	10¼
Do. Electro, Apr.	73	16	8
Solid drawn tubes		15½d.	
Brazed tubes		15½d.	
Wire		12d.	
Yellow metal rods		8½d.	
Do. 4x4 Squares		10½d.	
Do. 4x3 Sheets		10¼d	

BRASS.

Solid drawn tubes	13½d.
Brazed tubes	16½d
Rods	12½d.
Sheets to 10 w.g.	11½d.
Wire	11½d.
Rolled metal	11¼d.

TIN.

	£	s.	d.
Standard cash	181	0	0
Three Months	182	15	0
English	178	0	0
Bars	180	0	0
Chinese	174	0	0
Straits	187	0	0
Australian	187	0	0
Eastern	184	10	0
Banca	195	0	0
Off. aver., cash, Apr.	164	0	11⅞
Do. 3 mths., Apr	166	19	4½
Do. Sttlment., Apr.	164	0	0
Aver. spot, Apr.	163	19	3½

SPELTER.

	£	s.	d.
Ordinary	27	5	0
Remelted	23	10	0
Hard	17	0	0
Electro 99.9	35	10	0
English	31	0	0
India	22	0	0
Prime Western	28	5	0
Zinc dust	50	0	0
Zinc ashes	6	0	0
Off. aver., Apr.	26	1	5⅝
Aver., spot, Apr.	25	10	7

LEAD.

	£	s.	d.
Soft foreign ppt	23	15	0
English	24	15	0
Off. average, Apr.	20	16	10½
Average spot, Apr.	20	11	9½

ZINC SHEETS.

	£	s.	d.
Zinc sheets, spot	36	0	0
Do. V.M. ex. whf	36	0	0
Do. ppt., f.o.b., N.Y.		—	
Dutch	35	0	0
Boiler plates	32	10	0
Battery plates	32	0	0

ANTIMONY.

	£	s.	d.
English regulus	37	0	0
Special brands	42	0	0
Chinese	24	10	0
Crude	18	10	0

QUICKSILVER.

	£	s.	d.
Quicksilver	11	2	6

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50%	£17 5 0
75%	£24 0 0
Ferro-vanadium—	
35/40%	24/6 lb. va.
Ferro-molybdenum—	
70/80%	8/- lb. mo.
Ferro-titanium—	
23/25%, carbonless	1/6 lb.
Ferro-phosphorus, 20/23%	£32
Ferro-tungsten—	
80/85%, carbon free	1/10 lb.
Tungsten metal powder—	
98/99%	2/3 lb.
Ferro-chrome—	
4/6% car.	£37 0
6/8% car.	£36
8/10% car.	£35 10
Ferro-chrome—	
Max. 2% car.	£84
Max. 1% car.	£100
Max. 0.75% car.	£115
65/75%, carbonless	2/9 lb.
Nickel—99·8%, cubes or pellets	£195
Cobalt metal—97%	18/- lb.
Aluminium—98/99%	£150
Metallic Chromium—	
98/99%	6/6 lb.
Ferro-manganese—	
76/80%, loose	£22
76/80%, packed	£23
76/80%, export	£19
Metallic manganese—	
98/99%, carbonless	3/- lb.
Per ton unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 3 0
Finished bars, 18% tungsten	3 9
Scrap pieces	5d.
Turnings and swarf	3d.
Per lb. net, d/d buyers' works.	
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Flats under 1 in. by ¼ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness	3d. lb.
Bevels of approved sizes and sections	6d. lb.
If in coils	3d. lb.
Packing	4s. cwt
Bars cut to length	10% extra
Scrap from high-speed tool steel—	
Scrap pieces	5d.
Turnings and swarf	3d.
Per lb. net, d/d steel makers' works.	

SCRAP.

	£	s.	d.
South Wales—£ s. d.			
Heavy Steel	3	0	0
Bundled steel & shearings	3	0	0
Mixed iron & steel 1 0 0	3	10	0
Heavy cast iron	3	15	0
Good machinery for foundries	5	10	0
Cleveland—			
Heavy steel	2	10	0
Steel turnings	2	7	6
Cast-iron borings	2	7	6
Heavy wrought iron piling	3	10	0
Bundling scrap	4	5	0
Cast-iron scrap	5	10	0
Lancashire—			
Cast iron scrap	6	0	0
Heavy wrought	3	0	0
Steel turnings	1	10	0
London—			
Copper (clean)	50	0	0
Brass (clean)	30	0	0
Lead (less usual draft)	17	10	0
Tea lead	15	10	0
Zinc	13	0	0
New aluminium cuttings	70	0	0
Braziery copper	40	0	0
Gun metal	45	0	0
Hollow pewter	130	0	0
Shaped black pewter	75	0	0

PIG-IRON.

	£	s.	d.
N.-E. Coast—			
Foundry No. 1	125/-		
Foundry No. 3	120/-		
Forge No. 4	117/6		
Mottled	117/6		
Hematite No. 1	162/6		
Hematite M/Nos.	160/-		
Midlands—			
Staffs. common	145/-		
,, part-mine forge	160/-		
,, ,, foundry	170/-		
,, Cold blast	320/-		
,, basic	140/-		
Northants forge	140/-		
,, foundry No. 3	147/6		
,, basic	140/-		
Derbyshire forge	150/-		
,, foundry No. 3	160/-		
,, basic	150/-		
Scotland—			
Foundry No. 1	170/-		
,, No. 3	165/-		
Hematite M/Nos.	180/-		
Sheffield (d/d district)—			
Derby forge	155/-		
,, foundry No. 3	160/-		
,, basic	155/-		
Lincs. forge	160/-		
,, foundry No. 3	170/-		
,, basic	162/6		
E.C. hematite	173/-		
W.C. hematite	196/-		
All d/d in the district.			
Lancashire (d/d eq. Man.)—			
Derby forge	—		
,, foundry No. 3	170/-		
Northants foundry No. 3	—		
Cleveland foundry No. 3	—		
Staffs. foundry No. 3	—		
Lincs. forge	172/6		
,, foundry No. 3	177/6		
Summerlee foundry	193/-		
Glengarnock foundry	195/6		
Gartsherrie foundry	193/-		
Monkland foundry	193/-		

FINISHED IRON & STEEL.

Iron—	£	s.	d.
Bars (cro'n)	19	0	0
Angles	19	10	0
Tees to 3 united ins.	20	0	0
Nut and bolt	19	0	0
Hoops	23	0	0
Marked bars (Staffs.)	27	10	0
Gas strip	22	0	0
Bolts and nuts, ¾ in. × 4 in.	38	0	0
Steel—			
Ship plates	19	0	0
Boiler plates	25	0	0
Checquer plates	20	0	0
Angles	17	10	0
Tees	18	10	0
Channels	18	0	0
Joists	17	10	0
Rounds, ¾ in.–3-in.	14	10	0
Rounds, 3 in.–5½ in.	13	10	0
Flats, 5 in.–8 in.	15	0	0
Flats over 8 in.	13	10	0
Rails, heavy	15	0	0
Fishplates	20	0	0
Hoops	17	10	0
Black sheets, 24 g.	19	10	0
Galv. cor. sheets, 24 g.	22	0	0
Galv. fencing wire, 8 g. plain	23	10	0
Rivets, ¾ in. dia	27	0	0
Billets, soft	11	10	0
Billets, hard	12	10	0
Sheet and tin bars	11	10	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s.	d.
½ in. to 1 in. wide	1	9½
1 in. to 1½ in. wide	1	9½
1½ in. to 2 in. wide	1	7½

Strips.	s.	d
2 in. to 6 in. to 26 S.W.G.	1	7½
6 in. to 12 in. to 26 S.W.G.	1	7½

Sheets.	s.	d.
12 in. to 18 in. to 24 S.W.G.	1	7½
18 in. to 24 in. to 24 S.W.G.	1	8½
24 in. to 30 in. to 20 S.W.G.	1	9½
30 in. to 36 in. to 16 S.W.G.	1	9¾
36 in. to 42 in. to 16 S.W.G.	1	10¾

Extras.

For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

Drawn Rods.	s.	d.
¼ in. to ⅛ in. dia. in random lengths; 9/16 in. to 1½ in. dia. in random lengths	1	8
Over 1½ in. to 1¾ in.	1	8

Tubes—basis price 1 9¾

Delivery 2 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/1 to 1/7
Rolled—	
To 9 in. wide	1/8½ to 2/2½
To 12 in. wide	1/9 to 2/3
To 15 in. wide	1/10 to 2/4
To 18 in. wide	1/11 to 2/5
To 21 in. wide	2/- to 2/6
To 24 in. wide	2/1 to 2/7
Ingots for spoons and forks	1/1 to 1/7
Ingots rolled to spoon size	1/4 to 1/10
Wire round—	
3/0 to 10. G.	1/11 to 2/6

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	26.26
No. 2 foundry Valley	24.50
No. 2 foundry, Birm.	23.00
Basic	24.96
Bessemer	26.96
Malleable	26.96
Grey forge	25.46
Ferro-manganese 80 % delievred	90.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	37.00
O.-h. billets	37.00
O.-h. sheet bars	39.00
Wire rods	48.00
	Cents.
Iron bars, Phila.	2.35
Steel bars	2.10
Tank plates	2.20
Beams, etc.	2.20
Skelp, grooved steel	2.20
Skelp, sheared steel	2.20
Steel hoops	2.75
Sheets, black, No. 28	4.00
Sheets, galv., No. 28	5.00
Sheets, blue an'l'd, 9&10	3.10
Wire nails	3.25
Plain wire	3.00
Barbed wire, galv.	4.00
Tinplate, 100-lb. box	$6.25

COKE.

Welsh foundry	67/6
,, furnace	55/-
Durham & North. foundry	70/-
,, furnace	42/6
Other Districts, foundry	77/9
,, furnace	45/-

SWEDISH IRON.

Bars, hammered basis sizes Basis price	£35 to £37
Rolled Ordinary— Assortment ..	£ s. d. 22 10 0 to 23 10 0
Nail Rods— Square, round and flats ..	
Keg Steel } about Faggot Steel } £40	Prices nominal.
Blooms— Single welded ..	£16 to £18
Billets— Single and double welded ..	£18 to £23
Pig-Iron— Grey, white or mottled ..	£12/10 to £14

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas ..	—15%	—20%
Water ..	— 5%	—11¼%
Steam ..	+ 6¼%	— 1¼%

TINPLATES.

I C. Cokes,	20×14, box	27/-
„	28×20, „	53/-
„	20×10, „	37/-
„	18¾×14, „	30/-
I.X.	„	70/-
I.X.X.	„	90/-
F.C.B.Y.	21×13⅝ „	50/6
C.V.B.G.	16½×15, „	50/-
I.C.W.	20×14, „	21/6
„	28×20, „	39/6
„	20×10, „	28/6
„	18¾×14, „	18/-
Terneplates,	28×20, „	54/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.	
May11	72	0	0	No change
„ 12	72	12	6	inc. 12/6
„ 13	73	2	6	„ 10/-
„ 16	—			—
„ 17	74	2	6	„ 20/-

Electrolytic Copper (Cash).

May11	73	10	0	inc. 10/-
„ 12	73	10	0	No change
„ 13	74	0	0	inc. 10/-
„ 16	—			—
„ 17	74	10	0	inc 10/-

Standard Tin (cash).

May11	178	10	0	inc. 100/-
„ 12	179	0	0	„ 10/-
„ 13	178	10	0	dec. 10/-
„ 16	—			—
„ 17	181	0	0	inc 50/-

Tin (English Ingots)

May11	176	0	0	inc. 20/-
May12	176	0	0	No change
„ 13	175	10	0	dec. 10/-
„ 16	—			—
„ 17	178	0	0	inc. 50/-

Zinc Sheets (spot).

May11	36	0	0	No change
„ 12	36	0	0	No change
„ 13	36	0	0	No change
„ 16	—			—
„ 17	36	0	0	No change

Spelter (ordinary).

May11	26	10	0	No change
„ 12	26	10	0	No change
„ 13	26	10	0	No change
„ 16	—			—
„ 17	27	5	0	inc. 15/-

Lead (English).

May11	25	5	0	inc. 5/-
„ 12	25	5	0	No change
„ 13	24	10	0	dec. 15/-
„ 16	—			—
„ 17	24	15	0	inc. 5/-

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(*Continued on page* 466.)